VOLUME XLIX NUMBER 4 WHOLE 429

SCHOOL SCIENCE AND MATHEMATICS

APRIL 1949

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

All matter for publication, including books for review, should be addressed to the editor. Payments and all matter relating to subscriptions, change of address, etc. should be sent to the business manager.

Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879. Published Monthly except July, August and September at 450 Ahnaip St., Menasha, Wis. PRICE. Three dollars and fifty cents a year; foreign countries $4.00; current single copies 40 cents.

Contents of previous issues may be found in the Educational Index to Periodicals.

Copyright 1949, by the Central Association of Science and Mathematics Teachers, Inc.

GLEN W. WARNER
Editor
Lakeville, Indiana

RAY C. SOLIDAY
Business Manager
Box 408, Oak Park, Ill.

DEPARTMENTAL EDITORS

BOTANY—Joseph P. McMenamin
Oak Park Township High School, Oak, Park, Ill.

CHEMISTRY—Kenneth E. Anderson
University of Kansas, Lawrence, Kan.

CHEMISTRY RESEARCH—B. S. Hopkins
The University of Illinois, Urbana, Ill.

ELEMENTARY SCIENCE—Anna E. Burgess
Supervisor of Elementary Science, Cleveland, Ohio

GENERAL BIOLOGY—John E. Potzger
Butler University, Indianapolis, Ind.

GENERAL SCIENCE—Walter A. Thurber
State Teachers College, Cortland, N.Y.

GEOGRAPHY—Villa B. Smith
John Hay High School, Cleveland, Ohio

MATHEMATICS—George E. Hawkins
Lyons Twp. High School and Junior College, LaGrange, Ill.

Cecil B. Read
University of Wichita, Wichita, Kan.

MATHEMATICS PROBLEMS—G. H. Jamison
State Teachers College, Kirksville, Mo.

NATURE STUDY—E. Laurence Palmer
Cornell University, Ithaca, N.Y., and the Americain Nature Association

PHYSICS RESEARCH—Joseph D. Elder
Harvard University Press, Cambridge 38, Mass.

SCIENCE DEMONSTRATIONS—Shailer A. Peterson,
American Dental Association, Chicago, Ill.

ZOOLOGY—Howard F. Wright
Eli Lilly & Company, Indianapolis, Ind.

For individual student use

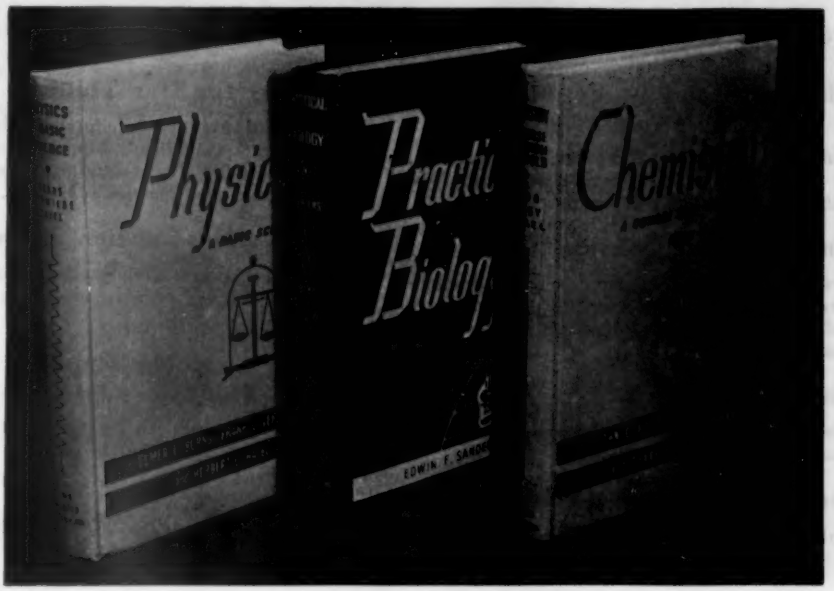
Human Manikin

The Turtox Human Manikin comes to you as a sheet size 22 by 30 inches, containing drawings and complete directions. You cut out and assemble the various figures (coloring them if you wish) and you then have a splendid reference manikin of the human body approximately one-seventh natural size.

Per hundred manikins $12.00

Per dozen manikins 1.75

GENERAL BIOLOGICAL SUPPLY HOUSE
Incorporated
761-763 EAST SIXTY-NINTH PLACE
CHICAGO 37, ILLINOIS
The Sign of the Turtox Pledges Absolute Satisfaction



New Editions of Successful Science Texts

PHYSICS: A BASIC SCIENCE. ***By Burns, Verwiebe, and Hazel.*** New edition of an outstanding text. Brings the book up-to-date in all developments. New editions of Workbook, Laboratory Manual, and Guide.

PRACTICAL BIOLOGY. ***By Sanders.*** Second edition of a successful new biology. Improved illustrations and added self-pronouncing glossary. Teacher's Guide ready. Workbook published this spring, containing 60 varied assignments, special home projects, section on microscope.

CHEMISTRY: A COURSE FOR HIGH SCHOOLS. ***By Hogg, Alley, and Bickel.*** New second edition of text and laboratory manual. Industrial applications still emphasized. All recent discoveries included. New tables.

Are you changing texts in any of these subjects?

D. VAN NOSTRAND COMPANY, INC.

250 FOURTH AVENUE, NEW YORK 3

Science and Mathematics Books for Today

The Earth and Its Resources

New Second Edition

Finch, Trewartha, Shearer. New material on all phases of physical geography. New Laboratory Manual by Shearer.

Understanding Science

Crouse. Explains modern science developments, such as atomic energy, jet engines, radio, and television, through easy-to-grasp analogies.

Radar Primer

Hornung. Simplified, entertaining presentation for high school students.

Chemistry for Our Times

Weaver and Foster. Life-interest chemistry emphasizing principles. Interest-topics sequence. *Chemistry Text-Films* available. Laboratory Manual and Teacher's Manual.

New Directions in Science Teaching

Laton and Powers. New methods and projects, usable under regular classroom conditions.

Practical Shop Mathematics

New Third Edition

Wolfe and Phelps. An extensive revision of Volumes I and II.

Fieldbook of Natural History

Palmer. More than 2000 descriptions of birds, fish, plants, rocks, minerals, animals, and the stars.

McGraw-Hill Book Company, Inc.
330 West 42nd Street **New York 18, N.Y.**

Mathematics by Teacher-Authors:

SCHORLING • CLARK • SMITH

Algebra: First Course

Modern-School Geometry: New Edition

Mathematics in Life—Basic Course

Mathematics for the Consumer

World Book Company • YONKERS-ON-HUDSON 5, NEW YORK
2126 PRAIRIE AVENUE, CHICAGO 16

What are you planning for summer and for your future teaching career? The colleges are offering some excellent short courses and workshop activities. SCHOOL SCIENCE AND MATHEMATICS *will give the help you need throughout the year.*

CONTENTS FOR APRIL, 1949

Antibiotics—*W. Brooks Fortune* 259

Looking Forward to the 1949 Convention—*Charlotte L. Grant* 264

Duke Mathematics Institute—*W. W. Rankin* 264

An Investigation of the Subject-Matter Backgrounds of Student Teachers in Science—*George Greisen Mallinson* 265

A Simple Demonstration Hydraulic Ram—*Frank Hawthorne* 272

The Spiral Development of Arithmetic—*Lucile B. Gates* 273

Club Notes—*G. F. Bradfield* 280

Teaching Science for General Education in the Secondary School—*G. P. Cahoon* 281

Scientists Are Queer—*Jerome B. Davis* 288

Problems of Biology in General Education—*Prevo L. Whitaker* 289

Summer School Work for Physics Teachers—*Elmer Hutchisson* 295

Mathematics in General Education—*Raleigh Schorling* 296

Why Study Mathematics?—*Bjarne R. Ullsvik* 302

The Community. A Teaching Unit in Ecology—*John P. Wessel and Paul A. Meglitsch* 309

The Quiz Section—*Julius Sumner Miller* 321

Eastern Association of Physics Teachers. One Hundred Sixty-Eighth Meeting—*A. R. Clish, Secretary* 322

Dictoforms—*P. H. Nygaard* 328

Experiments Concerning the Resistance of Water—*Martin H. Patrick* 329

Problem Department—*G. H. Jamison* 331

Books and Pamphlets Received 335

Book Reviews 337

WE COVER THE EARTH

School Science and Mathematics is read by subscribers in every state of the Union, all provinces of Canada, and thirty-three foreign countries.

It is owned by teachers, managed by teachers, and edited by teachers.

It comes to your desk every school month.

Interesting Articles in Volume 48

The Columbia Basin Project—Modern Trends in Mathematics Education—Covering Old and New Ground—Science for All—Some Ethical Implications of Science—The Control and Beneficial Use of Atomic Energy—A Museum Teaches—Phantom Forests—Putting Meaning into Geometric Concepts—Crater Lake—Geography in Farwestern Institutions of Higher Learning—Making the Most of Astronomy in High School Science—Developing Understanding in Junior High School Arithmetic—Map Clinic—Yearbooks and Science Education—What Makes the Weather Change? Fifth Grade Science Unit—Mathematics for the Other Eighty-five Per cent.

Helpful Reprints and Supplements

Atomic Energy: A Science Assembly Lecture, illustrated	.25
Mock Trial of B versus A—A play for the Mathematics Club	.30
100 Topics in Mathematics—for Programs or Recreation	.25
Poison War Gases	.20
Popular Mathematics: Bibliography	.10
Mathematics Problems From Atomic Science	.25
The Mathematics of Gambling	.20
Computations With Approximate Numbers	.25
The Radical Dream—A Mathematical Play for Puppets	.15
Geometry Theorems: A List of Fundamentals	.15
How Water Serves Man. A teaching unit	.20
Biology Reading List	.10
Won by a Nose. A chemistry play	.25
Some War-Time Developments in Chemistry—48 pp.	.50
Radioactive Isotopes: A Science Assembly Lecture, illustrated	.25
Kem: Two Games for Chemistry Classes	.15
Modern Periodic Arrangements of the Elements; illustrated	.25
Ion Visits the Realm of Air. A Play	.25
The King of Plants. A play for science clubs	.25
Three Families of Great Scientists: dramatized	.15
Some Lessons About Bees. A 32-page booklet; illustrated	.20
The Triumph of Science. A play for auditorium programs	.25
In a Sound Studio. A play: Physics and Music	.25
Science Library. Recent books for high schools	.10
Youth Looks at Cancer. A biology play	.25
Laboratory Work in Single Periods: Method	.15
Apparatus for Demonstrating the Fundamentals of Radio	.20
Science in the Grades: Practical Contributions—35 pp.	.30
Extracting Aluminum. A one act chemistry play	.15
Vitalizing Chemistry Teaching. A Unit on the Halogens	.15
Telescope Making Illustrated	.25
A Scientific Assembly Program, Wonders of Science	.30
What Is Scientific Method?	.20
The Scientific Method as a Teaching Procedure	.30
Elementary School Science Library	.10
Projection Demonstrations in General Science	.20
Atomic Energy—A Play in Three Scenes	.30

Orders for Reprints must be prepaid.

SCHOOL SCIENCE AND MATHEMATICS

Price $3.50—Foreign $4.00

No numbers published for July, August and September

P.O. Box 408 Oak Park, Ill.

How to Prepare Your Science Order Without Writing a Single Word!

It can be done—as thousands of science teachers have discovered.

The apparatus, reagents and specimens you'll need for Physics, Chemistry and Biology can be ordered, quickly and accurately, without putting one word on paper.

How? By using the CamboscO Order Book, whose pages are designed to serve as order forms. You are thus absolved from the time consuming chore of copying long want lists.

Compact—but Comprehensive

There's no need to hunt through half a dozen bulky catalogs to locate the materials you want for student experiments, or for your demonstration work.

In the CamboscO Order book you'll find descriptions and prices for 7781 items, of which 1601 are pictured. Throughout the listing of apparatus, numbered illustrations are interpersed, for instant identification.

Detailed Dimensional Data

For every piece of apparatus that is made in more than one size, complete dimensional data are given. Pyrex Test Tubes, for example, are offered in twenty sizes and styles. For each, the listing shows length, diameter, rubber stopper size, price per dozen, number in case and price per case.

This unique method of listing, in which a single page equals two or three pages of an old style catalog, eliminates some "sales talk," but omits none of the information essential for intelligent choice.

For teachers who prefer them, there is included a liberal supply of conventional order blanks, printed on special paper, on which it is easy to write with hard pencil, soft pencil, ink, or ball point pen. Those perforated blanks have proved especially convenient for interim orders.

An Annual Publication

Once a year, the CamboscO Order Book is painstakingly revised, from cover to cover. New items are added. Obsolete or unavailable materials are dropped. Prices are brought up-to-date at the moment of publication.

Free—to Teachers of Science

The CamboscO Order Book is furnished, without charge or obligation, to science teachers and to school officials.

Your free copy of the current edition will be sent postpaid on receipt of your teaching address.

CAMBOSCO SCIENTIFIC COMPANY
37 ANTWERP STREET • BRIGHTON 35
BOSTON, MASS., U.S.A.

Preparation of Manuscripts for Publication in School Science and Mathematics

MANY articles come to our editorial office before they have been put in condition for our use and hence must be rejected. The spelling, punctuation, sentence structure, and all mechanics of the manuscript should be correct before it is submitted. Do not count on making such corrections when you receive the galley proof. All changes in proof mean extra expense. This journal is not endowed and all expenses must be paid out of receipts from subscriptions and advertising. It is a cooperative enterprise. Make your original manuscript exactly right and perfectly clear.

Papers for publication should be sent to **Glen W. Warner, Editor, Lakeville, Indiana.** Return postage should be included if the manuscript is to be returned if rejected.

Manuscripts submitted should not have been published elsewhere. They should be original typewritten copies, double or triple-spaced with wide margins on 8½" x 11" paper.

References and footnotes should be numbered consecutively throughout the article and indicated by superior numbers. The reference or footnote should be set off by rules and placed immediately below the citation.

Bibliography should be given thus:
FRANKLIN, G. T. "Analysis in First Year Chemistry," *Journal of Chemical Education,* 7, pp. 361-364, February, 1930.

Drawings should be made on good quality white paper in black India ink. Letters, numbers, etc., which cannot be set in type at the margin of the cut must constitute a part of the drawing. They should be proportioned to insure legibility in the cut. Illustrations to appear as full page productions should be proportioned suitable for a 4" x 7" page.

Tabular Material should be proportioned to suit page width. All tables should be double ruled at the top just below table number and heading; use single rulings for columns, sub-divisions and bottom. References to illustrations and tables should be by number, as "see Fig. 3," and not to position, as "the following table." It may not be possible to set the drawing or table at a specific position with respect to the discussion.

Reprints are supplied only when ordered and at approximate prices quoted on Reprint Order Card which will be sent you with galley proof. Orders for less than one hundred reprints cannot be accepted.

Read galley proof as soon as received, indicate corrections clearly in pencil and return to the Editor immediately.

1948-49 OFFICERS OF C.A.S.M.T.

President, Charlotte L. Grant, Oak Park High School, Oak Park, Ill.
Vice-President, Paul L. Trump, University of Wisconsin, Madison, Wis.
Secretary, Cecilia J. Lauby, Indiana University, Bloomington, Ind.
Treasurer, Ray C. Soliday, Oak Park High School, Oak Park, Ill.
Historian, Edwin W. Schreiber, State Teachers College, Macomb, Ill.

BOARD OF DIRECTORS

J. E. Potzger, President 1947-48
F. Olin Capps
Missouri Conservation Commission, Jefferson City, Mo.
Ella Marth
Harris Teachers College, St. Louis, Mo.
Walter N. Smith
East Technical High School, Cleveland, Ohio
Philip Tapley
Wells High School, Chicago, Ill.
Ralph W. Lefler
Purdue University, Lafayette, Ind.
Donald W. Lentz
Ridge Road School, Parma, Ohio
Lorne M. McKenzie
Upper Canada College, Toronto, Ontario
H. Vernon Price
University High School, Iowa City, Iowa
Arthur C. Brookley
Thornton Township H.S. and J.C., Harvey, Ill.
Martha E. Curtis
State Normal College, Ypsilanti, Mich.
Philip Peak
Indiana University, Bloomington, Ind.
Mary A. Potter
Board of Education, Racine, Wis.

SECTION OFFICERS

Biology

Ch.—Robert H. Cooper
Ball State Teachers College, Muncie, Ind.
V. Ch.—Donald O'Brien
Thornton Township High School, Harvey, Ill.
Sec.—Frances M. Gourley
LaPorte Senior H.S., LaPorte, Ind.

Chemistry

Ch.—Carl E. Ekblad
Senior High School, Moline, Illinois
V. Ch.—Clyde W. Dewalt
Glenbard High School, Glen Ellyn, Ill.
Sec.—Gerald Osborn
Western Michigan College, Kalamazoo, Mich.

Elementary Mathematics

Ch.—Esther E. Cowley
Oakman School, Detroit, Mich.
V. Ch.—J. R. Mayor
University of Wisconsin, Madison, Wis.
Sec.—Lucile B. Gates, Sawyer Avenue School, Chicago, Ill.

Elementary Science

Ch.—Viola Neuman
Miles Standish School, Cleveland, Ohio
V. Ch.—Viola Hendrickson
Girls Latin School, Chicago, Ill.
Sec.—Albert Piltz
Roosevelt School, Detroit, Mich.

General Science

Ch.—Donald A. Boyer
Skokie Jr. H.S., Winnetka, Ill.
V. Ch.—Russell Shedd
Redford Union High School, Detroit, Mich.
Sec.—Fred Fox
Miami University, Oxford, Ohio

Geography

Ch.—Floy Hurlbut
Ball State Teachers College, Muncie, Ind.
V. Ch.—Laura L. Watkins
Lincoln School, Cicero, Ill.
Sec.—Mabel Washburn
Shortridge High School, Indianapolis, Ind.

Mathematics

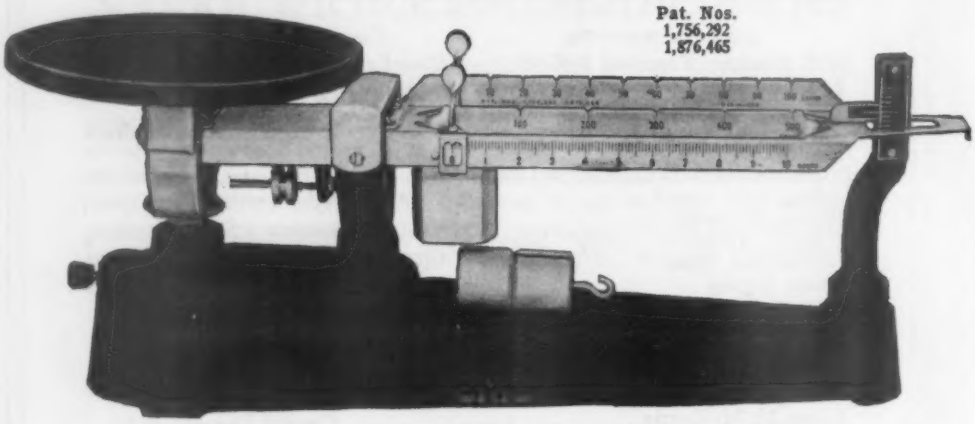
Ch.—William E. Edwards
Redford High School, Detroit, Mich.
V. Ch.—E. H. C. Hildebrandt
Northwestern University, Evanston, Ill.
Sec.—Enoch D. Burton
Shortridge High School, Indianapolis, Ind.

Physics

Ch.—J. Leo Walton
Western High School, Detroit, Mich.
V. Ch.—J. S. Richardson
Ohio State University, Columbus, Ohio
Sec.—Delia Redman
New Haven High School, New Haven, Ind.

Please Mention *School Science and Mathematics* when answering Advertisements

WELCH *Stainless Steel*
TRIPLE BEAM TRIP-SCALE



No. 4050

THE BEAM AND ALL EXPOSED PARTS ARE MADE OF
STAINLESS STEEL

even to the tiny screw, rivet or nut used in assembling this superior balance.

CAPACITY	SENSITIVITY
1,610 grams	0.1 g

AGATE BEARINGS
COBALITE KNIFE EDGES
ETCHED SCALES
STABLE AND WELL DAMPED

Complete with two extra weights

EACH $18.00

Write for Circular

W. M. Welch Scientific Company

Established 1880

1515 Sedgwick St. Dept. S Chicago 10, Ill. U.S.A.

Manufacturers of Scientific Instruments and Laboratory Apparatus

SCHOOL SCIENCE
AND
MATHEMATICS

VOL. XLIX APRIL, 1949 WHOLE NO. 429

ANTIBIOTICS*

DR. W. BROOKS FORTUNE
The Lilly Research Laboratories, Indianapolis, Indiana

One of the most outstanding and rapid developments in the field of chemistry during the last short decade has been that of antibiotics. During this short period of ten years, since 1939, the chemical and particularly the pharmaceutical chemical industry, together with university research organizations, has investigated and developed the production of penicillin from the test tube to a multimillion dollar a year industry.

Although many involved definitions have been given for the term "antibiotics," one may define it simply by stating that antibiotics consist of those metabolic products, normal or induced, produced during the growth of a microorganism, which will inhibit the growth of other microorganisms. Microorganisms include yeasts, molds, actinomycetes, bacteria, viruses, etc. Recently it has been found that antibiotic materials may also be produced by certain plants, for example, the antibiotic "tomatin" being produced by a certain South American form of tomato plant.

As far back as 1877, Pasteur noted that the development of anthrax was inhibited in the presence of other bacterial species. At about the same time he postulated that the rapid disappearance of pathogens from the soil was due to the presence of other bacteria. This theory provides material for controversy among bacteriologists even today.

Probably the first beginning of the study of antibiotics reverts back to 1889 when the French scientist Bouchard reported that a blue crystalline pigment material produced by *B. pyocyaneous*

* Presented before Chemistry Section, Central Association of Science and Mathematics Teachers, Inc. Indianapolis, Indiana, November 26, 1948.

(*Pseudomonas aerogenosa*) inhibited growth of some other bacteria. He named the chemical "pyocyanine." A little later a second material named "prodigiosine" was found to be produced by *Chromobacterium prodigiosum*. It was not until 1932 that this latter substance was again isolated, shown to have definite activity, and studied chemically.

In 1929, Dr. Alexander Fleming, a bacteriologist at St. Mary's Hospital in London, noted that a culture of *S. aureus* which had been contaminated with an airborne mold showed zones of inhibition on the plate around the contaminant. He identified the mold as *Penicillium notatum*, noted its effect against a few organisms and its low toxicity in animals, but then dropped any further study on it. Raistrick carried on a little further in 1932 but dropped his work also after publishing a short paper. For seven years nothing more was done, until 1939 when Dr. H. W. Florey, professor of pathology at Oxford University picked up the work with almost spectacular results. At about the same time Dubos at Rockefeller Institute had isolated "tyrothricin," so it was natural that when the war slowed down Florey's work in England, Rockefeller Institute brought him to the United States in 1941 for consultation and to continue the work in this country. Shortly thereafter when the value of penicillin became apparent to U. S. medical authorities, our Government supported several manufacturing companies, and Universities having adequate research facilities, in a joint research project intended to place penicillin in production for the use of the Armed Forces as quickly as possible.

The penicillin project rapidly resolved itself into two phases: (a) the isolation of a higher producing strain and growth in deep culture as opposed to the surface culture then in use, and (b) the purification and crystallization of the final product.

In 1943 the best culture isolated at the Northern Regional Research Laboratories was capable of producing about 150 Oxford units per milliliter in surface culture. By 1944 cultures were being grown in deep tanks, "submerged culture," but with a yield of only 90 units/ml. With the aid of Peoria housewives who contributed moldy food, and a little research luck, late that year there was isolated from a moldy cantaloupe a culture which was capable of producing as high as 200 units/ml. This culture was sent to several college research groups and as a result of x-ray irradiation at Carnegie Institute and screening at Minnesota and Wisconsin Universities a higher-producing culture was isolated capable of doubling previous yields and producing 400 units/ml. In 1946, at the University of Wisconsin, the x-rayed culture was then irradiated with ultraviolet light and another new culture was isolated (designated Q-176) which could

produce more than 800 units/ml. in submerged growth. It is this last culture which is used in most manufacturing plants today. During these years more than 100,000 isolated cultures were tested at the Northern Regional Research Laboratories.

The chemist had not been idle during these years. His problem was two-fold, (a) to aid in forcing the mold to grow the desired type of penicillin, and (b) to purify the final product to a point where it could be crystallized.

Early in the work it was discovered that the naturally growing mold produced several forms of penicillin differing chemically from each other only in the composition of a side chain from a complex nucleus. Several forms of penicillin were isolated and identified. These were named as follows:

Name	*Side chain*
G	benzyl
X	p-hydroxybenzyl
F	2-pentenyl
Dihydro F	n-amyl
K	n-heptyl

It was noted that certain of these were much more effective clinically than others. For example, penicillin K disappeared from the blood stream very rapidly and therefore, was relatively ineffective. So the chemist set about to synthesize a chemical compound (a precursor) which could be introduced into the medium on which the mold grows and which would force the mold to produce a large proportion of the desired type of penicillin. After much experimentation, it was found that penicillin G was produced almost exclusively when phenylacetic acid or a derivative thereof was introduced into the growing medium. Thus it was now possible not only to grow large amounts of penicillin, but also to grow the desired kind. A forthcoming monograph will describe in detail all of the research work done on "precursors."

In the early days, the final purified product consisted of a yellow, amorphous powder which was relatively unstable and required storage at refrigerator temperatures. While the theoretical purity of sodium penicillin is about 1667 Oxford units per milligram, the early material had a purity of only 200 units. As the chemists continued their work the purity of the final product rose to 1400–1500 units/mg. Finally, in 1946, the day came when crystalline penicillin became a reality. From simple organic solvents, such as ketones and alcohols, it was possible to crystallize either the sodium or potassium salt of penicillin at theoretical purity and as a pure white material.

Yet the chemist had not completed his work. Using sodium or potassium penicillin, it was necessary to inject a dose of penicillin

intramuscularly every three hours in order to maintain a clinically effective level in the blood. Why not develop a compound which would be absorbed more slowly and yet would maintain a clinically effective blood level over a much longer period of time? During 1947 the chemists combined a great many substances with penicillin in an attempt to form the desired "insoluble penicillin." One of our researchers found that when he added a water solution of procaine hydrochloride to a water solution of sodium or potassium penicillin a white precipitate formed, procaine penicillin. When suspended in oil, and injected intramuscularly, this material maintained blood levels over a twenty-four hour period. Thus it was now necessary to give injections only once a day instead of every three hours as before. Recently the chemists have found that the addition of a small amount of aluminum monostearate to the oil suspension gives a product which will maintain blood levels for a period up to a week. Thus injections are further reduced.

Whereas penicillin was a chance discovery, streptomycin was the result of a deliberate search for a specific antibiotic effective against tuberculosis. Waksman, at the New Jersey Agriculture Experiment Station isolated a great number of microorganisms before finding a culture of *Streptomyces griseus* which produced the desired antibiotic. In much the same manner as described before for penicillin work, this microorganism from the soil was cultured and subcultured to find a higher producing culture. While the results have not been as spectacular as with penicillin, the production ability of the organism has slowly been increasing through continued work.

The purification of streptomycin has not yet progressed to the point where crystalline streptomycin is available, although double salts with calcium chloride have been prepared. However, almost pure amorphous material is commercially available now. Only recently, the chemists have found a new form, dihydrostreptomycin, which apparently has less lasting toxicity than previously. This material is produced by hydrogenating streptomycin, thereby reducing an aldehyde group.

The commercial production of penicillin or streptomycin consists of two phases, the fermentation and the purification. The fermentation might be likened to a farming process. Seed is planted in small tanks where it grows for two or three days and is then transferred under sterile conditions to large fermenters ranging in size from 2,000 to 20,000 gallons capacity. After two or three more days, these fermenters are "harvested" and the filtered broth or "beer" is then purified. Usually enough fermenters are available so that one or more are harvested each day, and an equal number of new seeds are planted each day. The mold grows on a medium consisting of protein,

sugar and salts. The common practice of the industry today is to use "corn steep liquor," a by-product of the corn starch industry, as the source of protein. Sugar is available as syrup or in dry form. The mold requires large quantities of air for growth just as humans. This is usually bubbled into the medium from the bottom of the tank. Freedom from contamination is a necessity, since the presence of other growing microorganisms in the medium tends to form enzymes which destroy the penicillin activity.

The purification of penicillin consists of a solvent extraction method wherein the penicillin is extracted from the beer into an organic solvent, usually amyl acetate or similar compounds, leaving the excess chemicals required for growth behind in the waste beer. Then the penicillin is extracted consecutively into a water solution, back into another organic solvent and finally again into water as the sodium or potassium salt in order to remove color and impurities. By various methods, most of which are considered trade secrets, the penicillin is then crystallized into crude crystals and these are either recrystallized into final, pure white, theoretically pure penicillin which you may purchase at your pharmacy, or are made into procaine penicillin which will be suspended in peanut oil or sesame oil to be sold as the "long lasting" product requiring only daily or longer injections.

Contrary to the penicillin process, the purification of streptomycin consists of an adsorption-elution process. The activity is adsorbed on some active material, usually activated charcoal, and is then eluted off with an organic solvent at low pH. Further purification consists of concentration, removal of toxic substances and color and finally drying, either under high vacuum from the frozen state or drying on hot drums in vacuum.

Both products must pass very rigid tests set up by the Food and Drug Administration, a department of the U. S. Government, before release to the ultimate consumer. These tests are made in order to determine that the product meets standards of potency, toxicity, moisture, etc.

What does the future hold in the field of antibiotics? There is an old saying, "the world will beat a path to the doorstep of the man who invents a better mousetrap, even if he should live in the middle of a forest." So it will be in the field of antibiotics. Only the surface has been scratched, the horizons are wide. The next ten years will undoubtedly bring many more new discoveries, probably extending into antibiotics effective against viruses such as polio, rabies, influenza, and possibly effective against even the common cold. The chemist and the bacteriologist and microbiologist have joined forces and such a combination can only result in the advance of science.

LOOKING FORWARD TO THE 1949 CONVENTION

The Central Association of Science and Mathematics Teachers will hold its forty-ninth convention in Chicago at the Edgewater Beach Hotel on November 25 and 26. The program of the November meetings will be developed around the implementation of science and mathematics in everyday teaching and living. Plans are being made to complete the program by May 21 in order that the meetings may be publicized through educational conferences and journals.

The Local Arrangements Coördinator will be Mr. Milton D. Oestreicher. If you have suggestions or recommendations for the 1949 convention, won't you kindly list them on a postcard and mail to Mr. Oestreicher, Francis W. Parker School, 330 W. Webster, Chicago, or myself? We shall welcome your coöperation for this is your Association and your convention.

Next year, 1950, will witness a half-century of history-making events in The Central Association of Science and Mathematics Teachers. Several anniversary projects are already under development. One of these is an anniversary publication about which you will hear more in the near future.

CHARLOTTE L. GRANT *President*

DUKE MATHEMATICS INSTITUTE

August 8–19, 1949

The ninth annual session of the Institute for Mathematics Teachers (High School and College) will be held at Duke University, Durham, N.C. August 8–19, 1949.

There will be ten study groups under the leadership of teachers of national recognition. The general theme of the Institute will be "Mathematics at Work"

Study Groups;

I. Aids in the Study of Algebra
II. Outdoor Work in Mathematics
III. Modern Geometry with Applications
IV. Arithmetic of Home, Business, and Industry
V. Graphical Analysis with Applications
VI. Junior High School Mathematics
VII. The Slow Student in Mathematics
VIII. Applications of Mathematics
IX. Laboratory Mathematics (Junior-Senior High School)
X. Laboratory Mathematics (High School—College)

Twenty Speakers of note are on the program representing, industry, business, education, science, and engineering.

Special emphasis will be given to social events during the Institute.

Programs with detail information will be ready April 1.

W. W. Rankin
Professor of Mathematics, Duke University
Director of Mathematics Institute

AN INVESTIGATION OF THE SUBJECT-MATTER BACKGROUNDS OF STUDENT TEACHERS IN SCIENCE

GEORGE GREISEN MALLINSON
Western Michigan College of Education, Kalamazoo, Michigan

INTRODUCTION

It is common knowledge that the science teachers in the rural highschools, and in the smaller urban highschools, are frequently assigned to the teaching of all of the subject-matter fields in the science program during a biennial period. These fields usually include Physics, Chemistry, General Biology, Earth Science and General Science. Further, it is in these smaller highschools that the newly-graduated science teachers usually receive appointments. However, it is dubious whether or not these newly-graduated science teachers are sufficiently trained in all of these science fields to teach them adequately. It is consequently of importance to determine whether or not their training may be overspecialized in one or more of the fields of science.

PURPOSE

It was therefore the purpose of this study to determine the extent to which the subject-matter backgrounds of student teachers in science vary with respect to the different fields of science.

PROCEDURES

Four separate tests in each of the fields of Earth Science, Physics, Chemistry and Biology were constructed in the following way. The Regents Examinations of the University of the State of New York for the years 1944 and 1945 were selected as the source of the various test items. These examinations are prepared by the State, and are used to measure the achievement of high-school students after a year's study in the respective subject-matter areas. They were selected as the source of the test items since data were available concerning the average score received on each of the test items by a representative sampling of over 1,000 students taking them.

First, from Part I of the examinations on Earth Science was taken a random sampling of thirty short-answer questions, to each of which was assigned a value of one point. Each of these questions was written on a sheet of paper together with the average score received by the students who had answered that question. Next, were selected thirty short-answer questions from the examinations on Biology. These questions, however, were selected so that each of the questions

on the examination on Earth Science was matched with a question on the examination on Biology with respect to the average score received by the students who had answered it. This same procedure was used in selecting thirty items for the examination on Physics, and for the examination on Chemistry.

From the thirty items on each of the four examinations, twenty-five were selected and so matched that the average scores on the corresponding items in the four tests varied by not more than .02 of a point. It could be assumed, therefore, using the average score obtained by the sampling of students taking these examinations, that the tests were of almost the same difficulty.

A similar procedure was used for selecting an essay type question from Part II or III from each of the Regents examinations. From Part III of the examination on Earth Science was selected a question, having a value of 10 points, requiring the application of a scientific principle for each of five parts. Then, from either Parts II or III of the examinations on Biology, Physics and Chemistry was selected a similar type of question, whose average scores on the basis of the pupils' marks, did not vary more than .2 of a point from the average total score of the examination question on Earth Science. It could, therefore, be assumed that these questions were of almost the same difficulty.

For the purposes of this study, a .02 point difference in difficulty was allowed between the short-answer items, and a .2 point difference in difficulty on the essay type questions, because a 3 per cent correction error is allowed by the State for determining the passing grade of 65 per cent on the examination when used by the high-schools. A 3 per cent variation on a one point short-answer item would be .03 and on a 10 point item .2. However, prorated on the basis of the passing grade of 65 per cent, rather than on the perfect-score basis, the variation would be .02 for a one point item and .2 on a 10 point question.

The items were then made into a composite test of 100 items, 25 from each of the four areas, Earth Science, Biology, Physics and Chemistry, in that order for Part I. Part II consisted of one five-part question in Earth Science, followed by a corresponding question in each of the fields of Biology, Physics and Chemistry.

This composite test in the sciences was then administered on a trial basis to eleven students who were science majors at Iowa State Teachers College to determine the approximate time needed for the final administration. It was found that all of the students taking the examination on the trial basis finished in one and three-quarters hours. It was therefore arbitrarily decided to limit the time on the final administration of the test to two hours, preferably in one period.

In case this plan should prove impracticable, it was arbitrarily decided that the test could be given in two consecutive class periods, each of one hour in length. The test subjects were to be allowed to begin on Part II before the end of the first hour, provided that they had completed Part I, but in any case they were to start on Part II at the end of the first hour. They might use any time remaining after the completion of Part II for rechecking either Parts I or II. All tests were to be turned in at the expiration of the two-hour period.

Five state teachers colleges and one university school of education, all in the midwestern part of the United States, agreed to participate in this study, in accord with the plans set up for administering the composite test. During the months of April and May of 1948, the composite tests were administered to all the student teachers in science at the secondary level in these institutions, and were returned to the writer for scoring. The short-answer items were assigned a value of one point each and each essay question was assigned a value of twenty-five points, five points for each part. The total possible score was therefore 200 points. In order to reduce the possibility that a low score on the final section of Part I or II might be caused by failure to complete that section, those tests were discarded on which the last four items of Part I, or the last two sections of Part II, had not been answered. Seventy-nine usable tests were thus obtained. The results were then tabulated and analyzed.

Analysis of Results

The results were first tabulated on the basis of the mean scores obtained by the students in each school, and then for all the schools combined. Table 1 summarizes the results.

Table 1

Mean Scores By School on Short-Answer, Essay Type and Composite Tests

School	Short-Answer				Essay Type				Composite Score			
	Earth Science	Biol.	Phys.	Chem.	Earth Science	Biol.	Phys.	Chem.	Earth Science	Biol.	Phys.	Chem.
A	9.69	8.69	6.15	4.23	4.92	5.62	3.54	.54	14.61	14.31	9.69	4.77
B	10.88	12.55	15.44	12.88	12.44	15.55	16.11	10.22	23.32	28.10	31.55	23.10
C	14.38	16.90	16.10	12.08	17.20	21.15	16.77	5.62	31.58	38.05	32.87	17.70
D	12.90	15.50	12.00	11.40	14.60	18.10	14.44	6.25	27.50	33.60	26.40	17.65
E	12.25	18.05	13.30	13.50	14.60	15.95	13.45	7.95	26.85	34.00	26.75	21.45
F	9.31	11.00	6.89	4.44	5.31	7.56	5.94	.69	14.62	18.56	12.83	5.13
All Schools	11.49	14.00	11.40	9.62	11.32	13.58	11.24	4.96	22.81	27.58	22.64	14.58

Using the data in Table 1, the "*t*" test of significance was applied to determine the significance of the differences between the mean

scores of the various tests. The use of the "t" test is cited by Guilford.[1] The "t's" were determined for the differences between the highest mean score and the lowest mean score on the short-answer tests, and similarly for the essay type examination, and for the composite scores. For example, for School A on the short-answer test, "t" was determined for the difference in means between the score on Earth Science and the score on Chemistry, which were the highest and lowest respectively. For School B, on the composite test, "t" was determined between the means of the score on Physics and the score on Chemistry, which were the highest and lowest respectively. Tables 2, 3 and 4 summarize the results.

TABLE 2

Calculated Values for Scores on Short-Answer Questions from Table 1

School	Mean Difference	S.E. Mean Difference	"t"	Probability Level	Interpretation
A	5.46	5.48	.99	$P > .05$	No signif. gain
B	4.56	6.45	.71	$P > .05$	No signif. gain
C	4.82	6.04	.79	$P > .05$	No signif. gain
D	4.10	5.55	.74	$P > .05$	No signif. gain
E	5.80	5.10	1.14	$P > .05$	No signif. gain
F	6.56	4.94	1.33	$P > .05$	No signif. gain
All Schools	5.38	7.97	.68	$P > .05$	No signif. gain

TABLE 3

Calculated Values for Scores on Essay Type Questions from Table 1

School	Mean Difference	S.E. Mean Difference	"t"	Probability Level	Interpretation
A	5.08	3.99	1.27	$P > .05$	No signif. gain
B	5.89	9.76	.61	$P > .05$	No signif. gain
C	15.53	6.81	2.29	$P < .05$	Signif. gain
D	11.85	8.54	1.39	$P > .05$	No signif. gain
E	8.00	8.88	.90	$P > .05$	No signif. gain
F	6.87	3.90	1.76	$P > .05$	No signif. gain
All Schools	8.62	10.06	.86	$P > .05$	No signif. gain

The results of the test were then retabulated for each school, and for the total group in the following way. The scores made by each student on the short-answer tests for each of the four fields of science were arranged in ascending order. Thus, when the mean scores for each school were computed, the individual scores may have been from any one of the four fields of science. Therefore, the lowest mean

[1] Guilford, J. P., *Psychometric Methods*. New York: McGraw-Hill Book Co., 1936, pp. 61–2.

TABLE 4

Calculated Values for Composite Scores from Table 1

School	Mean Difference	S.E. Mean Difference	"*t*"	Probability Level	Interpretation
A	9.84	5.35	1.84	$P > .05$	No signif. gain
B	8.45	14.06	.60	$P > .05$	No signif. gain
C	20.35	12.70	1.60	$P > .05$	No signif. gain
D	15.95	10.95	1.46	$P > .05$	No signif. gain
E	12.55	12.76	.98	$P > .05$	No signif. gain
F	13.43	6.57	2.05	$P > .05$	No signif. gain
All Schools	13.00	16.90	.77	$P > .05$	No signif. gain

score for each school was computed from the sum of the lowest scores of each student in that school, disregarding the field of science. The second lowest mean score was computed from the sum of the second lowest score for each student and so on for each of the remaining scores on the short-answer examination. A similar computation and tabulation was made using four scores received by each student on the essay type questions, and for the composite scores. Finally, all students were considered as one group and computations were made on the group basis in the same manner. Table 5 lists the information just cited.

TABLE 5

Mean Scores Obtained on the Basis of Ascending Order of Scores from Four Fields of Science

School	Short-Answer				Essay Type				Composite Score			
A	3.46	6.08	8.00	11.23	.15	2.23	4.23	8.00	4.38	8.46	12.92	17.62
B	9.44	11.44	13.11	17.77	7.33	11.44	14.33	21.22	17.66	23.00	26.88	38.55
C	10.54	14.46	16.15	18.30	5.46	14.15	18.85	22.31	16.69	29.69	34.23	39.61
D	9.75	11.63	13.63	16.75	4.50	12.38	16.88	19.63	14.88	24.63	29.75	35.88
E	10.00	12.35	15.50	19.25	6.05	11.30	15.50	19.10	18.25	24.10	29.85	37.85
F	3.32	6.68	9.19	12.25	.68	3.44	6.31	9.06	4.31	11.13	15.88	19.81
All Schools	7.57	10.38	12.63	15.94	3.89	8.81	12.34	16.06	12.48	19.76	24.61	30.79

Using the data in Table 5, the "*t*" test of significance was applied to determine the significance of the differences between the mean scores for each of the schools and for the combined scores of all schools. "*t*" 's were determined for the differences between the highest and lowest mean scores as listed in Table 5 for the short-answer test, essay type questions and for the composite scores. Tables 6, 7 and 8 summarize the results.

INTERPRETATION OF RESULTS

From the data in Tables 2, 3 and 4 there is no consistent evidence that in any particular school, students are, as a group, significantly

TABLE 6

Calculated Values for Scores on Short-Answer Questions from Table 5

School	Mean Difference	S.E. Mean Difference	"t"	Probability Level	Interpretation
A	7.77	4.36	1.78	$P>.05$	No signif. gain
B	8.33	6.69	1.25	$P>.05$	No signif. gain
C	7.86	3.37	2.33	$P<.05$	Signif. gain
D	7.00	5.38	1.31	$P>.05$	No signif. gain
E	9.25	5.05	1.83	$P>.05$	No signif. gain
F	8.93	3.29	2.41	$P<.05$	Signif. gain
All Schools	8.37	4.18	2.03	$P<.05$	Signif. gain

TABLE 7

Calculated Values for Scores on Essay Type Questions from Table 5

School	Mean Difference	S.E. Mean Difference	"t"	Probability Level	Interpretation
A	7.85	3.33	2.36	$P<.05$	Signif. gain
B	13.89	6.70	2.08	$P>.05$	No signif. gain
C	16.85	7.81	2.16	$P>.05$	No signif. gain
D	15.13	7.08	2.15	$P>.05$	No signif. gain
E	13.05	7.43	1.76	$P>.05$	No signif. gain
F	8.38	2.91	2.88	$P<.05$	Signif. gain
All Schools	12.17	5.20	2.34	$P<.05$	Signif. gain

TABLE 8

Calculated Values for Composite Scores from Table 5

School	Mean Difference	S.E. Mean Difference	"t"	Probability Level	Interpretation
A	13.24	5.60	2.37	$P<.05$	Signif. gain
B	20.89	11.88	1.76	$P>.05$	No signif. gain
C	22.92	12.04	1.91	$P>.05$	No signif. gain
D	21.00	12.40	1.69	$P>.05$	No signif. gain
E	19.60	9.41	2.02	$P>.05$	No signif. gain
F	15.51	5.83	2.66	$P<.05$	Signif. gain
All Schools	18.31	9.15	2.00	$P<.05$	Signif. gain

better trained in one field of science than in another. This is also true when the students from all six schools were considered as a single group.

There is one exception, that being in School C where students as a group scored significantly better on the biology essay questions than on the chemistry essay questions. This however is but one case of twenty-one.

It may be noted, however, that, although no consistent significance may be attributed to the differences between the means as computed in Tables 1 through 4, the mean scores on the biology examination were the highest in sixteen of the twenty-one cases tabulated, while the mean scores on the chemistry examination were lowest in nineteen of the twenty-one cases tabulated.

The data from Tables 6, 7 and 8 indicate that there are many positive differences which are fairly certain. These positive differences are significant, when students are taken both by schools and as a total group, if the best scores without regard to the field of science, are compared with the poorest mean scores computed in the same way.

When considered in this way, at least one positive difference was found to be significant in three of the participating schools, between the means of the best and poorest scores on either the short-answer test, essay type test, or composite scores. When all students were considered as a single group, the positive differences between the means of the best and poorest scores were significant on the short-answer test, essay type test and composite scores. The positive differences were significant, therefore, in nine of the twenty-one cases in Tables 6, 7 and 8.

Therefore, although there is no definite evidence that the participating schools, taken singly or as a group, stress the same field of science in training individual students, there is evidence that the student is prepared significantly better in some one field, that field varying with the student.

Although newly-graduated science teachers are frequently expected to teach all fields of science, insofar as the results of this study are valid, there is fairly certain evidence that the training in the separate fields of science is poorly balanced, although not generally in favor of any one field.

Recommendations

Insofar as the results of this study are valid, the following recommendations seem worthy:

1. That further study be undertaken to determine whether or not the imbalance of training in science among newly-graduated science teachers is evident in teacher-training institutions other than those participating in this study.

2. That further study be undertaken to determine whether or not the imbalance in training in science among newly-graduated science teachers affects the learning of the high-school students in areas in which these teachers are least qualified.

3. That further study be undertaken to determine how the im-

balance in training among newly-graduated science teachers, if such imbalance interferes with good teaching, may be corrected by in-service training, or prevented by modifying curricular requirements in teacher-training institutions.

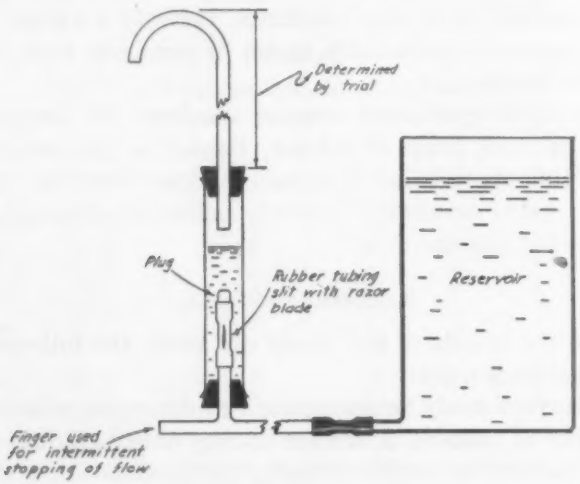
A SIMPLE DEMONSTRATION HYDRAULIC RAM

FRANK HAWTHORNE
Hofstra College, Hempstead, N. Y.

With a head of one foot and a flow of five feet from the reservoir to the valve, the hydraulic ram shown in the diagram will raise water at least four feet above its initial level.

A Bunsen valve is used to prevent backflow. The tube from the reservoir should be of fairly large diameter. All rubber tubing joints (particularly those near the ram) should be as short as possible. The corks should be seated firmly in the large vertical tube. If the delivery tube extends into the large vertical tube, an air chamber is created which makes the flow somewhat more regular. The vertical tubes should, of course, be supported.

This device is easy to make, requires only the simplest materials, and its action is readily understood by students.



HYDRAULIC RAM

Christiaan Huygens, Dutch mathematician, astronomer, and physicist, was born at The Hague on April 14, 1629.

THE SPIRAL DEVELOPMENT OF ARITHMETIC*

LUCILE B. GATES
Sawyer Avenue Elementary School, Chicago, Illinois

"The demands of modern living make arithmetical competence one of the real imperatives." I came across this statement recently. I don't know who the author of it is, but I'm sure we all agree with the truth expressed in it or we would not be here attending this convention and learning better methods of teaching.

The important role that the elementary school plays in the teaching of arithmetic was very forcibly brought home to me a short time ago. At a luncheon for secondary teachers of mathematics, we found at our places two mimeographed sheets of paper bearing the title: "From the Second Report of the Commission on Post-War Plans," and below this title was the explanatory statement: "The essentials for competence in mathematics are put as questions in the following check list." And then followed 28 questions on arithmetic. I presume that most of this audience is made up of elementary grade teachers and, if that is so, it is unlikely that you have seen this list which I believe was distributed to high school teachers only. On the chance that you have not seen it, I have distributed copies of it to you to-day and I think this list of 28 questions is important enough to be read now.

FROM SECOND REPORT OF THE COMMISSION ON POST-WAR PLANS

The essentials for functional competence in mathematics are put as questions in the following Check List:

1. Can the pupil operate effectively with whole numbers, common fractions, decimals and per cents?
2. Has he fixed the habit of estimating an answer before he does the computation and of verifying the answer afterward?
3. Does he have a clear understanding of ratio?
4. Is he skillful in the use of tables (including simple interpolation) as, for example: interest tables, tables of roots and powers, trigonometric functions, income tax tables, etc.?
5. Does he know how to use rounded numbers?
6. Can he find the square root of a number by table or by division?
7. Does he know the main guides that one should follow in collecting and interpreting data; can he use averages (mean, median, mode); can he make and interpret a graph (bar, line, circle, the graph of a formula, and of a linear equation)?
8. Does he have adequate ideas of point, line, angle, parallel lines, perpendicular lines, triangle (right, scalene, isosceles, and equilateral), parallelogram (including square and rectangle) trapezoid, circle, regular polygon, prism, cylinder, cone, and sphere?
9. Can he estimate, read, and construct an angle?
10. Can he use the Pythagorean relationship in a right triangle?

* Presented at the Elementary Mathematics section of the Central Association of Science and Mathematics Teachers at Indianapolis, November 26, 1948.

11. Can he with ruler and compasses construct a circle, a square, and a rectangle, transfer a line segment and an angle, bisect a line segment and an angle, copy a triangle, divide a line segment into more than two equal parts, draw a tangent to a circle, and draw a geometric figure to scale?

12. Does he know the meaning of a measurement, of a standard unit, of the largest possible error, of tolerance, and of the statement "a measurement is an approximation?"

13. Can he use certain measuring devices, such as an ordinary ruler, other rulers (graduated to thirty-seconds, to tenths of an inch, and to millimeters) compasses, protractor, graph paper, tape, calipers, micrometer?

14. Can he make a scale drawing and use a map intelligently—know the various forms employed in showing what scale is used—and is he able to find the distance between two points?

15. Does he understand the meaning of vector, and can he find the resultant of two forces?

16. Does he know how to use the most important metric units (meter, centimeter, millimeter, kilometer, gram, kilogram)?

17. In measuring length, area, volume, weight, time, temperature, angle and speed, can he convert from one commonly used standard unit to another widely used standard unit; e.g., does he know the relation between yard and foot, inch and centimeter, etc.?

18. Can he use letters to represent numbers; i.e., does he understand the symbolism of algebra—does he know the meaning of exponent and coefficient?

19. Does he know the meaning of a formula—can he, for example, write an arithmetic rule as a formula, and can he substitute given values in order to find the value of a required unknown?

20. Does he understand signed numbers, and can he use them?

21. Does he understand what he is doing when he uses the axioms to change the form of a formula or when he finds the value of an unknown in a simple equation?

22. Does he know from memory certain widely used formulas relating to areas, volumes, and interest, and to distance, rate, and time?

23. Does he understand the meaning of similar triangles, and does he know how to use the fact that in similar triangles the ratios of corresponding sides are equal?

24. Can he, by means of a scale drawing, develop the meaning of tangent, sine, and cosine, and can he use a three- or four-place table of these ratios to solve a right triangle?

25. Can he solve simple verbal problems (in arithmetic, algebra, geometry, and trigonometry)?

26. Does he have the information useful in personal affairs, home, and community; e.g., planned spending, the argument for thrift, understanding necessary dealings with a bank, and keeping an expense account?

27. Is he mathematically conditioned for satisfactory adjustment to a first job in business; e.g., has he a start in understanding the keeping of a simple account, making change, and the arithmetic that illustrates the most common problems of communications, travel, and transportation?

28. Does he have a basis for dealing intelligently with the main problems of the consumer; e.g., the cost of borrowing money, insurance to secure adequate protection against the numerous hazards of life, the wise management of money, and buying with a given income so as to get good values as regards both quantity and quality?

For a more detailed and definite statement see "The Role of Mathematics in Consumer Education"; single copies may be secured without cost from the National Association of Secondary School Principals, 1201 16th St. N.W. Washington, D.C.

Since this list was distributed to high school teachers, I felt that it was more or less of an indictment against the elementary school

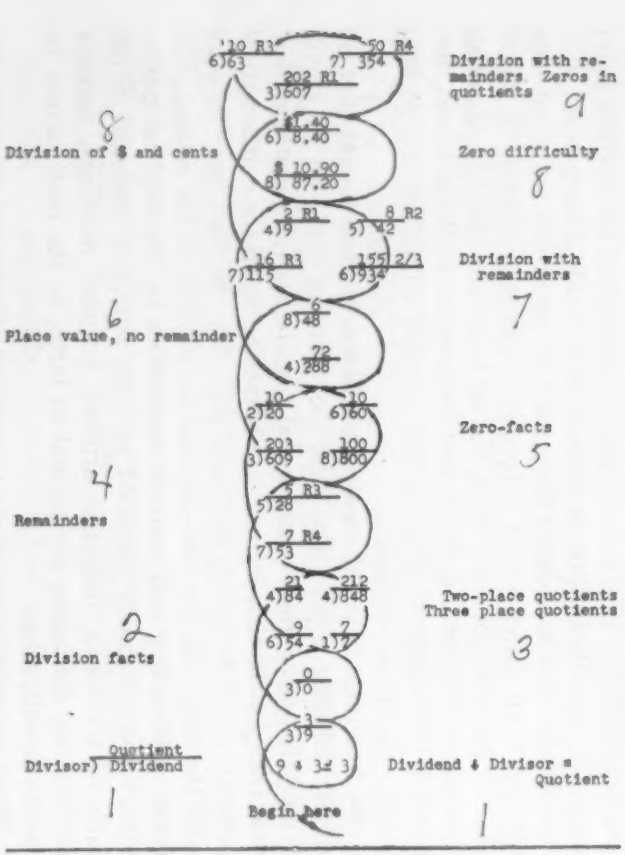
teachers of mathematics. After reading this list of questions carefully, you will observe that 17 of them are entirely within the elementary school level, and 9 are one-half to three-fourths covered before the pupil leaves the 8th grade. It implies, therefore, if we read between the lines, that if we, as the elementary school teachers, fail in our teaching of arithmetic, the secondary school teachers must take up the burden and do our work of teaching elementary mathematics.

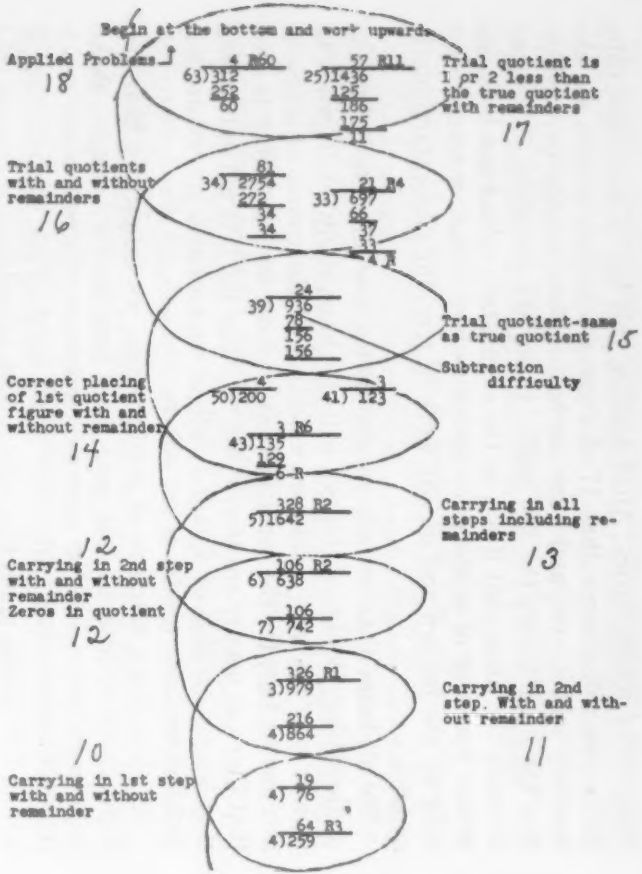
We all know that we will always have a few absolute failures in mathematics. We know that we will also have many pupils who can master only the very minimum essentials of the course of study in arithmetic, but, for the great majority, whose mental ability is such that they can master arithmetic, are we doing the best job of teaching that we are capable of doing? I believe we are; and yet we are not satisfied with the results of our efforts.

As elementary teachers of mathematics, we frequently hear the high school teachers of first year math breathe very deeply, shake their heads and sigh—"If only the elementary teachers would teach the kids plain simple arithmetic." And worst of all, this criticism is not limited to the math teachers. A high school sewing teacher told me that there were girls in her class who did not know how many inches there were in a quarter of a yard and could not measure it; and the shop teacher complains that boys in his class could not correctly measure a line 3 and $\frac{7}{8}$ in. long, and from others we hear that pupils can not divide by 17, 18 or 19, nor can they place the decimal point correctly in multiplication or division of decimals. I have heard such complaints—you have heard them too—and naturally we resent such comments on the effects or outcomes of our instructions. We know that we have taught these facts, but we know too, that in spite of all our efforts Johnny and Mary, and Tommy, and all the others, frequently show signs of never having heard of a fraction or a decimal point, or a "teen" divisor.

We hear now that the medical world has recently found that by simply inhaling a penicillin dust the common cold can be cured. Would that some great master mind would discover a mathematical dust that, by the simple process of breathing it, all the mathematical ailments could be cured. But until that day, we shall have to work with the drugs and the cure-alls that are already on the market. The many outstanding and eminent authorities in the field of mathematics have certainly provided us with abundant material in the form of textbooks, magazine articles, lectures, meetings, summer conferences, discussion groups and so forth, so the fault cannot be said to lie with them.

What we need is something to make mathematical facts, associa-


Division with remainders. Zeros in quotients
9
Division of $ and cents
8
Zero difficulty
8
Division with remainders
7
Place value, no remainder
6
Zero-facts
5
Remainders
4
Two-place quotients
Three place quotients
3
Division facts
2
Quotient
Divisor) Dividend
1
Begin here
Dividend ÷ Divisor = Quotient
1


Begin at the bottom and work upwards.
Applied Problems
18
Trial quotient is 1 or 2 less than the true quotient with remainders
17
Trial quotients with and without remainders
16
Trial quotient-same as true quotient
15
Subtraction difficulty
Correct placing of 1st quotient figure with and without remainder
14
Carrying in all steps including remainders
13
Carrying in 2nd step with and without remainder
Zeros in quotient
12
Carrying in 2nd step. With and without remainder
11
Carrying in 1st step with and without remainder
10

tions and understandings once taught, stick hard and long and fast. To be able to recognize at once, that in $10 \div \frac{2}{3}$, they invert the second term; but that in $10 \times \frac{2}{3}$ the second term stays as it is; that the formula $A = ba/2$ belongs to a triangle; that $C = 2r\pi$ refers to a circle; that 20% of a number means to multiply; but that in finding what per cent one number is of another they divide. Are we asking and expecting too much when we look for quickness and alertness in response to such questions? How can we make mathematics stick?

Dr. Brownell of Duke University believes that if teaching is made "meaningful" it has a good chance of sticking, and to the best of our abilities we do try to make our teaching of mathematics "meaningful," Dr. Morton of Ohio University places a good deal of faith in what he calls "telescoped reteaching," and that medicine has produced good results too, but it doesn't guarantee that sticking effect we need so badly. And so with many others—Dr. Brueckner of Minnesota, Dr. Buswell of Chicago, Dr. McSwain of Northwestern—all have suggested cures and preventives and remedies. It surely is not that we are lacking in good doctors with plenty of medicine for our ailing patients! But in spite of all the mathematical medication we give our pupils, we teachers of arithmetic, as the faithful nurses who administer the pills, painfully watch many of our pupils gradually expire and fill a mathematical grave yard.

We are not foolish enough to believe that all our patients should develop into able mathematicians; many are lacking in mathematical talent. Mathematical skill develops in much the same manner as a skill in an art or sport. Growth in any skill is gradual and success in each step in that developmental process must be mastered before advancing to the next step.

We teachers who have been through the process are prone to forget just how many steps are involved in the mastery of an arithmetical topic. If we can get an over-all picture of the topic in graphical form, I believe it would be a help to both teacher and pupil. I have found such a scheme helpful in the classroom and I shall try to describe to you how I make use of it.

In the two mimeographed sheets which have been given to you, I have tried to show how training in one of the basic arithmetical processes can be carried out.

For want of a better name and to add to the confusion already produced by the long list of terms used in their writings by mathematical reformers, such as "incidental," "telescoped," "purposeful," "individual" and numerous others, I have given my paper the title, "The Spiral Development of Arithmetic." As a matter of fact, the teaching of arithmetic should involve a combined use of all these pro-

cedures—it has to be meaningful, purposeful, retaught, reviewed, individual, incidental—it has to be a spiral development.

Learning is most likely to be successful if the child can see a definite reason for it or purpose to be accomplished. To teach division therefore, we must have a situation where the child sees a need for taking something apart. This situation may be the result of careful planning on the part of the teacher, it may have been purposely created or it may have come about incidently. Time does not permit me to go into minute details in this spiral development, but you notice in the small part, the beginning of the spiral, that the terms-dividend, divisor, quotient and remainder are established, the two methods of showing division are taught.

Again, while I have not shown in the spiral that sometimes we have a number that cannot be divided evenly, here would be the place to point out the remainder fact. I would illustrate the remainder idea by saying that I have 6 pieces of chalk for 4 children at the board. If I give each one a piece, I will still have 2 left over. That happens very often when we want to separate or divide a number of things that we cannot divide evenly. I will refer to a familiar home situation—the old favorite of cutting a pie. Usually, mother cuts the pie into 6 pieces, but if there are only 5 members in the family she would have 1 piece left over. We have another name for these left-overs—we call them remainders.

Now, as you examine the spiral development, you notice the steps getting broader and more difficult—new situations presenting themselves—the zeros, the correct placing of quotient figures, carrying in one step, in two steps and the trial divisors. You understand too that with each step, problems are solved and these problems increase in difficulty as the division becomes more complex.

Now you are apt to say—why all this fuss?—we know all this—we understand and realize these steps in the fundamental processes. That is true. Fundamental processes are the same, always have been and always will be, but, if we can find a way to help make them stick in the child's mind, we are helping not only the child, but I believe, we are helping ourselves, and at the same time, we are lessening the criticism that is too often erroneously heaped upon us.

I will tell you how I use the spiral development chart. I have classes in arithmetic from 5B thru 8A. When you come into my classroom you have no doubt as to what is being taught in that room—it fairly shouts arithmetic at you from the walls and tables. While I have taken division to illustrate the spiral development, I have large charts 24×36 showing the spiral development in the 4 fundamental processes. As I go around the room, if I find a pupil having zero difficulty in a problem, we go back over our spiral to the preceding step

where the zero was involved. Perhaps we go back 2 or 3 steps. The interesting thing about this is that most pupils resent my helping them over their difficulty—they like to look at the spiral chart and find the help they need for themselves. I doubt if they could or would take the time to hunt back through the pages in a textbook to find the help they need, but a picture is something different—it appeals to their imagination.

Another use that the pupils like to make of the spiral, is to test each other by it with problems in their spare time. Two or more will select a certain part of the spiral and put drill work on the blackboard for each other to work and correct. I have these spiral charts for decimals and fractions, for the three cases in percentage; for application of the three cases in discount, commission, profit and loss, interest; and for the four major rules in percentage. I also have them for plane figures and solids. You know by now that visual education by means of charts showing spiral development of arithmetic is my hobby—it is my ace in the hole.

My enthusiasm for the use and value of these spiral charts is contagious—I do not require the pupils to make them, but I lead them to see how valuable and helpful it would be for them to have a notebook size copy for themselves and they agree that it would—they build their spiral gradually as they reach each step.

I try to impress my pupils with the thought that there is a connection between all upward steps in arithmetic, that each new step rests upon all previous steps and that no step can be left out. That arithmetic forms a structural continuity, and that the only way to hold it together is by review, repetition, and illustration.

I did not come here to-day as an authority in the field of mathematics—I came here as one of you, a classroom teacher. I described to you simply a scheme or device that I have found helpful. What works for me, may not appeal to you. There may be those in the audience who have discovered tricks and schemes to help make arithmetic stick, that would be far better than my thinking of arithmetic processes as a spiral development. If so, I hope you are given an opportunity to express yourself. It is from these bits of interchange among teachers that I think we get a great benefit. If what I have said stimulates your thinking along these lines, then I will feel that I have accomplished some good toward our common aim.

In Chicago, under the sponsorship of Mr. Joseph Urbancek, head of the mathematics department at the Chicago Teachers College, the elementary teachers of mathematics have organized a club which is now in its 7th year. We meet four times during the school year, we have very fine speakers in the field of mathematics address our group. Our meetings are usually concluded by about 8:30 or 8:45 P.M., but it

is not uncommon for the principals and teachers who attend these meetings to sit around for an hour or so afterwards and discuss arithmetic in their schools and exchange ideas and methods.

Frequently we hear the comment that teachers are in a rut—don't you sometimes wish you could find a good deep rut and crawl into it for a while?

CLUB NOTES

Compiled by G. F. BRADFIELD

Many lists of problems have been proposed for one purpose or another. One such is "Mathematics For Christmas," by Joseph J. Urbancek. (This Journal, December 1948, page 678.) Following the same idea, it is hoped that the list set forth here will be of interest to many. It was used as a "Welcome to the Ladies" who were guests of the Men's Mathematics Club of Chicago at the annual joint meeting of the Men's and Women's Mathematics Clubs of Chicago and Metropolitan Area, March 19, 1948.

1. $W \sin^2 x + W \cos^2 x =$
2. $2 + \sum_{p=3}^{\infty} \frac{1}{p'} =$
3. $\frac{I(\sin^2 a \sec^2 a + 1)}{1 + \tan^2 a} =$
4. $\lim_{x \to 1} \frac{c \log_e x}{x - 1} =$
5. $y = xe^{-2x}$; at $x = \frac{1}{2}$, $y =$
6. $\frac{2m}{\pi} \int_0^{\infty} \frac{dx}{x^2 + 1} =$
7. $\lim_{n \to \infty} (1+n)^{1/n} =$
8. $\frac{2L(\csc^2 15° - \cot^2 15° + \sin 30°)}{3} =$
9. $\int_0^{\pi/3} a \cos y \, dy =$
10. $\frac{S - a}{n - 1} =$
11. $\lim_{y \to 0} \frac{e^{iy} - 1}{y} =$
12. $\lim_{x \to 0} (1 + \sin x)^{\cot x} =$
13. $\frac{a + b + c}{2} =$

Academic freedom is nothing more than a specific application of the freedoms inherent in the American way of life. It follows that to protect academic freedom, the teacher must support the entire free system which, among other things, guarantees freedom for all.

DWIGHT D. EISENHOWER

TEACHING SCIENCE FOR GENERAL EDUCATION IN THE SECONDARY SCHOOL[1]

G. P. CAHOON
Ohio State University, Columbus, Ohio

General education is concerned with the preparation of all the boys and girls of school age in our country. We are preparing the prospective garage mechanics, housewives, store clerks, beauty parlor operators, and aviators, as well as the future engineers, lawyers, business executives and research scientists. In only a few short years all will be men and women facing similar problems and duties of citizenship. Country-wide only about 20 per cent of youth in our high schools go on for further training in colleges or technical schools. Even if the recent large influx of students into college should continue and boost this figure to 25 or even 30 per cent, it is clear that only in the secondary school will there be an opportunity to meet the educational needs of *all* youth. Because, in a great many instances, the present high school program is not well adapted to the needs of a large proportion of pupils, there is a real challenge to make it effective for all.

There have been numerous reports giving serious consideration to the problem of general education in the American High School. Notable among the more recent of these are the Harvard Report, the Report of the Education Policies Committee, "Education for all American Youth" and the Cooperative Committee report on "The Present Effectiveness of Science Teaching."

While each of these reports differs somewhat in the specific type of curriculum organization proposed, it is noteworthy that each specifies certain experiences in science and mathematics to achieve the broad objectives which they estabish for general education. While science and mathematics might contribute in some degree to the achievement of all objectives, it seems more pertinent to consider here those objectives toward which these fields of learning may make their most substantial contribution.

In teaching science and mathematics for general education in the secondary school, then, we are confronted with three major problems which may be stated as questions:

1. What are the understandings, skills, and attitudes which science education can effectively help develop?
2. What is the nature of the content and of the pupil experiences which should be provided in high school science and mathematics programs?

[1] Read before the Central Association of Science and Mathematics Teachers at Indianapolis, November 26, 1948. A part of the Third Annual Forum of the AAAS Cooperative Committee on the Teaching of Science and Mathematics presented under the title "Problems of Science and Mathematics in General Education."

3. How can teachers be effectively prepared to carry out such science programs?

Understandings, Skills, Attitudes Relative to Science

In considering the first major question of the understandings, skills and attitudes which can be furthered by science education, there are four points which we feel are particularly important.

(1) *Education for citizenship is a primary concern of general education.*

If all pupils are to be prepared to live effectively in our culture, one of the most important common concerns is preparation for citizenship in a democracy. Of course this cannot be done by "pouring in" subject matter from books or lectures alone. Only by living and working together can human personality develop. It does not develop in a vacuum. The secondary school is therefore concerned with numerous common or "general" phases of living which are not limited to a series of separate subject matter courses, but cut across, or are even independent of typical traditional school areas.

Education for citizenship suggests that pupils have experiences which will give meaning and support to such principles of democracy as having a high regard for the individual and his development, and faith in the intelligence of the common man to solve his personal problems and those of concern to the community and state.

Specifically, in what ways can experiences in science courses aid in preparation for citizenship? With the developments of the last war so vivid in our minds and the problems of the post-war period forcing our immediate attention, we hardly need to be reminded of the role which science and technology is playing in modern living. The results are all around us from personal problems in the selection and preparation of foods, with freezers, electric stoves, and new packaging, fluorescent lights in home and office, movies and television for recreation, to those in the wider community, state and nation concerned with radioactive tracers, relief of cancer, new insecticides, jet propelled airplanes and huge plants for nuclear energy. Young people now in our schools in a few short years will be faced with all the personal, social, economic, political and international problems which these and countless other developments in science are bringing about. To deal intelligently as a citizen, even voting on problems concerned with preventive medicine, control of nuclear energy, or policies and practices relating to conservation, suggests the necessity that each individual in our society have some understanding of important science principles and facts.

(2) *Health education is important for general education.*

Another very important responsibility of the secondary schools which is "general" for all individuals is that of helping pupils to maintain optimum health, both physical and mental. The school needs not only to get information of the present status of each pupil's health condition when he enters, but to help him remedy limitations and to grow and develop a healthy mind in a healthy body.

There is still a great deal of superstition, misconception, and misunderstanding relating to health and disease. Every person needs to have enough understanding of science principles and facts to enable him to act intelligently on matters concerned with personal and community health. Many of the advertisements of radio and press, the thriving businesses of astrologers and patent medicine manufacturers, and the practices of factories in disposing of waste products testify to the misconceptions and apathy of our present citizens in important matters of health.

(3) *Critical thinking is important in general education.*

Many business men and critics of our schools, as well as college teachers, have advocated that pupils be taught "how to think rather than what to think." The secondary school has long accepted it as a most important goal that pupils learn how to think reflectively or critically rather than simply to memorize or accept without question the conclusions of others. The extent to which this objective has been achieved however, is open to question. Two phases relating to critical thinking should be stressed at this point.

(a) Critical thinking can be achieved not only in one or two areas like mathematics and science, but should be a goal sought for in all subject areas. It is not achieved automatically by exposing pupils to the "discipline" of certain subjects, valuable as they may be, when properly taught. Once this was the excuse for introducing Latin grammar. Taking courses in mathematics and science does not automatically enable pupils to think effectively, as many of you can testify.

(b) The so-called "scientific method" has often been advocated as "the" method which can and should be used to solve many if not all personal, social, economic, and practical problems. Numerous authors have listed the 5 or 7 steps[2] in this method which they claim scientists have used effectively in making important discoveries and in furthering the remarkable progress of science in the past few dec-

[2] See for example, John Dewey, *How We Think*, Heath Co., Boston, 1910; Selberg and Barnard, "Teaching Pupils the Method for Solving Problems," *Educational Method*, May 1937, P. 413–6; Carleton Preston, *The High School Science Teacher and His Work*, p. 107–8; Max Otto, "Scientific Humanism," *Antioch Review*, III 1943, p. 530–45.

ades. As has been pointed out by others,[3] it seems very questionable whether there is "a" method which may be called "the scientific method" which is unique to scientists, which has a sequence of steps that have to be followed, and which can be carried over bodily for the solution of problems in other areas. To suggest that the "steps" in and use of the scientific method can be taught in a course, so that high school pupils will be able thereafter to use this method in solving all manner of problems, is to propose a far-fetched hypothesis.

(4) *Effective personal and vocational guidance is important in general education.*

With all of the recent developments in science and technology there are of course countless opportunities for individuals seeking vocations and professions. Everyone should be guided into situations which will enable each of them to develop to the greatest degree indiviually and for society. This is now complicated. There are literally thousands of different kinds of jobs or vocations. Finding the aptitudes, interests, and potentialities of individuals to fit the vocational tasks needed is a challenge to modern education. This becomes even more an important problem when we take into consideration the problems created by increased leisure time, and the resulting concern for a wide variety of avocational pursuits, made more numerous and intriguing by developments in science. Such problems suggest guidance all the way from individual hobbies in photography or insect collecting to those relating to automobile driving and the establishment and use of national parks.

Content and Pupil Activities in Science and Mathematics

Relative to the question as to the nature of the content and pupil activities which should be provided in the science programs, there are also four points which need to be emphasized.

(1) *High school youth should have contact with each of the areas of mathematics, and biological and physical science.*

In order to live effectively in a world so full of the applications of mathematics, and biological and physical science, it seems hardly necessary to argue that all American youth should have experiences in all three of these areas. Whether they want to or not, those concerned with running a household, earning a living, working in a profession, or participating in the affairs of the community have to

[3] Compare, for instance, *Science Education in American Schools*, Part I, 46th Year Book, National Society for Study of Education, p. 166 ff; James Conant, *Education in a Divided World*, Chap. VII; *General Education in a Free Society*, Harvard Committee Report, Harvard University Press, 1945, p. 154–5; Commission on Secondary School Curriculum, Progressive Education Association, *Science in General Education*, Chapter VII.

deal with some phases of each of these three areas. To have contact with only one of them is to be inadequately prepared for responsibilities in our kind of world.

(2) *Are there "minimum essentials" in each of these areas?*

One of the important questions confronting the science and mathematics teachers in a program of general education is of course just what should be taught, what topics should be included, what subject matter should be covered. If there are some essentials with which all young folks in our culture should have contact, these should be determined and courses or experiences provided accordingly. Some of these will be suggested in the papers to follow on this forum. At least we are convinced that all pupils should have experiences with some of the important principles and their applications to everyday living in each area.

(3) *A course in physical science should be provided for the senior high school.*

For some years the course in biology has served to provide contact with this area rather than separate courses in botany and zoology. General mathematics has been provided as an alternate to specialized courses in algebra, geometry and trigonometry. A similar course is now needed in physical science for general education. This should not replace the courses in physics and chemistry which should continue to be provided for a selected group. This recommendation of course is not entirely new. The recent 46th Yearbook report on *Science in American Schools*[4] stresses the need for such a course. There have been for a number of years courses in many schools variously labeled "world science," "senior science," or "physical science" offered to juniors and seniors. Many such courses have not been too successful; others have been quite satisfactory. Our recommendation, however, includes the point that all pupils should take the course in biology, *and* the course in physical science, or physics or chemistry, or both.

By such a plan, elementary and general science would be offered in grades one through eight. Biology would be required in the ninth or tenth grade, physical science in the tenth or eleventh grade. Specialized courses in physics, chemistry, botany, zoology, physiology or other sciences would be elective. Pupils would have the opportunity, if they took the biology and the physical science course, to elect one or more of the special sciences. Such a plan or a modification of it, is already in operation in many of our best schools, and is one way of

[4] *Science Education in American Schools*, 46th Yearbook, Part I, National Society for Study of Education, University of Chicago, 1947, p. 190ff.

providing for some of the wide differences and needs in our unselected school population.

(4) *Science courses should provide for a wide variety of teaching procedures and a wealth of physical facilities, supplies and materials.*

If pupils are to have experiences of working together and developing individually toward participation in a democracy, opportunity for a wide variety of activities needs to be provided especially in courses for general education. Pupils with different abilities, interests, emotional maturity, and previous experiences learn and develop differently. The teacher of science has an unusually large array of teaching procedures and pupil experiences for possible use which include demonstrations, laboratory experiences and pupil projects, film strips, home made slides, motion pictures, recordings, field trips, directed study with supplementary materials, and committee reports. These also offer extensive possibilities for experiences in critical thinking.

The proposed courses in biological and physical sciences need not and should not be merely a rapid "covering" of large samplings of the enormous range of topics now possible in these areas. A few important topics, with experiences appropriate to the outcomes desired by means of demonstrations, projects or laboratory experiments, give promise of better understanding and appreciation. It is our contention that pupils in any science course need to have first hand experiences with the "real things" of science as well as reading about science. Hence we are not proposing merely a descriptive course.

Suitable science experiences may not be obtained without science materials. The science laboratory needs to be a work room where provision is made for this wide variety of experiences, with benches, tools, books, references, raw materials and apparatus which can be used when needed. Needless to say, in such a laboratory it is not expected always that each pupil is doing what every other one is doing. The laboratory may at times, at least, be available to use as a library is used, with the facilities available when pupils have time and interest to explore them, rather than only at fixed class times.

Preparation of Teachers

Regarding our third and last major problem, relating to the effective preparation of teachers for these kinds of courses, one of the questions which naturally arises is where are the teachers for such courses to be obtained? Obviously, they can come from only two sources: (1) the present teachers-in-service; and (2) teachers-in-training. So the question becomes how can each of these groups be prepared to teach such courses.

What present in-service-teachers can do

We have great faith in the ability and adaptability of the present science teachers. Many are already teaching these kinds of courses and utilizing such experiences and materials as those suggested. Many have started on the proverbial shoestring and with the help of their pupils and a few outsiders have provided adequate facilities and materials. This is an important and challenging problem. Of course, if teachers had more suitable facilities, it would be expected that they would provide suitable courses and pupil experiences. But we cannot and should not rationalize that we cannot do anything without the most desirable facilities and equipment. Specifically,

The individual can:

(a) Study the current literature.
(b) Initiate modifications in present teaching.
(c) Attend appropriate summer workshops.

The school can:

(a) Provide for science and mathematics curriculum study groups.
(b) Provide leadership for curriculum development by securing consulting services from universities and other sources.
(c) Provide time and facilities for such study groups (12-month contract).

Outside agencies (State Departments, Colleges and Universities) can assist by:

(a) Providing counselors.
(b) Providing appropriate workshop and in-service training programs for teachers of science and mathematics.

What should be the preparation of teachers-in-training?

While this problem of course needs study and experimentation, perhaps the previous recommendations of the Cooperative committee, as stated in the President's Scientific Research Board Report on *Manpower for Research*[5] would serve as a starting point:

"The following recommendations are made with regard to the preservice training of secondary school science and mathematics teachers:

(a) Certification should be in closely related subjects within the broad area of science and mathematics.

(b) Approximately one-half of the program, or 60 semester hours,

[5] President's Scientific Research Board, *Manpower for Research*, Vol. 4 of "Science and Public Policy." Washington, Government Printing Office, 1947, p. 59.

should be allotted to preparation in the comprehensive teaching area of science and mathematics.

(c) Every teacher of science and mathematics should complete the basic courses (6 to 10 semester hours each) in biology, chemistry mathematics, and physics.

(d) A minimum of 18 semester hours of study should be required for certification in a particular subject.

(e) The comprehensive area should include study beyond the basic course in at least two, and preferably three, of the sciences (the 60 semester hours will allow for 18 hours each in three subjects and the 6-hour basic course in a fourth).

(f) Certification for general science should require broad preparation, including college courses in all the subjects concerned in general science. The prospective general science teacher should meet the requirements suggested above and in addition should complete a one-semester basic course in astronomy and in geology."

SCIENTISTS ARE QUEER

Contributed by JEROME B. DAVIS
Lower Meridian Senior High School, Ardmore, Pa.

We have all met people who deride science. Scientists amuse them. Scientists do queer things and have such queer ideas. They make queer mistakes—well they're just a little queer themselves, you know.

A man harangued one of our editors in that vein the other day, for half an hour, while both rode to New York on a commuter's train, crossed on a ferry, rode again in a subway. "The world would be better off without it," he said, summing up against science and almost in the same breath he "knocked" the subway for being slow.

That man lives in a house that without the benefits of science would have been a dimly-lighted hovel, he travels on trains made possible only by science, and we noted conversed about the enjoyment of his radio (no science, no radio), his car (ditto), mentioned making a phone call (science), wore glasses fitted by science, and was literally surrounded by the results of science, of whose benefits and significance he never took time to reckon. And there are lots more like him.

We wished that, for a day, we could have abolished the conquests of science and set him back in the Ages of Faith, the early Middle Ages. He couldn't even get his face clean. Soap is a product of science. (Source unknown)

It is . . . shocking that millions of our children are not receiving a good education. Millions of them are in over-crowded, obsolete buildings. We are short of teachers, because teacher's salaries are too low to attract new teachers, or to hold the ones we have. All these school problems will become much more acute as a result of the tremendous increase in the enrollment in our elementary schools in the next few years.

—PRESIDENT TRUMAN

PROBLEMS OF BIOLOGY IN GENERAL EDUCATION[1]

PREVO L. WHITAKER
School of Education, Indiana University

Some years ago, biology began to supplant botany and zoology in the high school curriculum. The disposition of these, more formal courses, coincided with or followed closely the reversal of the relative position of the high school as a college preparatory school to that of a finishing school for the majority of its population.

At its constitutional meeting in July, 1938, the National Association of Biology Teachers wrote the following into its objectives:

A. "Facilitate the dissemination of that biological knowledge which is most vitalizing and useful to the public in everyday life."
B. "Make available to teachers information concerning the selection, organization, and presentation of biological materials; and the relationship of their subject to other sciences and education as a whole."[2]

In 1943, a committee on secondary school science curriculum, composed of eighteen members of Indiana school systems prefaced its report with a general statement regarding the aims of the teaching of biological science. It is believed that the biological sciences can and should be developed in such a way as to present fundamental concepts, not only as ends in themselves, but also to emphasize their contributions to the life needs of the child.

We find these objectives in the report of this group, "To help the student (1) gain in self-understanding and in social efficiency by a comprehension of the biological processes common to all living things, (2) develop the ability to apply biological principles to individual, family, and community health problems, etc., (3) develop an understanding of the part biology plays in selected vocations, (4) develop the ability to avoid fears, superstitions, and unsound taboos by the application of scientific knowledge and methods of thinking, and (5) develop an adequate social philosophy through the acquirement of an understanding of the biological phenomena affecting individual and community living. This philosophy would involve an increased tolerance of the wide variation in people and behavior; an intelligent attitude toward race relations; and a functional understanding of the evolutionary viewpoint and of the inter-relationships existing between all living things."[3]

---

[1] Read before the Central Association of Science and Mathematics Teachers at Indianapolis, November 26, 1948. A part of the Third Annual Forum of the AAAS Cooperative Committee on the Teaching of Science and Mathematics, presented under the title "Problems of Science and Mathematics in General Education."

[2] National Association of Biology Teachers, "Constitution and By-Laws," Article II, 1938.

[3] Unpublished report of the Indiana State Committee on Secondary School Science Curriculum, 1943.

For many pupils, especially those who will not go beyond high school, biology will be the last formal contact with science instruction. "An analysis of the United States Office of Education Statistics reveals the fact that a majority of the secondary school students of the nation are not continuing science education beyond general science and biology."[4]

Biology is not only very probably the last, but it is the first science instruction for practically all pupils commuting from one and two room grade schools; unless general science, is offered in the ninth grade, followed by biology in the tenth, biology is the only science course they will ever have. Only in those rare cases where the teacher of the one room grade school takes it upon herself to provide some opportunity for them to study their environment in a critical manner is any effort made to eliminate superstitious beliefs and unsound modes of thinking, which limit those children's outlook on life. Science teachers in high schools which receive pupils from both these rural schools and from consolidated or town grade schools are aware of the ever-widening breach between the two groups.

It has become the responsibility of the high school biology teacher to reconcile his course with the talents and interests of two groups—those who are going on to college and those who are not. It seems advisable to introduce ideas which are closely related to the life of the individual and which embrace problems pertaining to health, sanitation, conservation of natural resources, sex education, genetics, and the inter-relationship of varied forms of life and their significance. For those whose formal education will not extend beyond high school, these are important components of a broader knowledge of life and an enlightened outlook.

It would seem that it is chiefly because of its flexibility that biology has replaced botany and zoology in the general high school. Because it can come close to the life of the individual in a descriptive manner, and because it can provide a continuity of the general science instruction pattern, with only a minor shift toward specialization, biology probably makes a greater contribution to the education of the pupil who will not become a scientist. It is better, even for the pupil who may later become a science specialist, if the program follows a more general pattern. At the ninth and tenth grade levels, general science, followed by a year of general biology provides such a program. There is hardly time to specialize in two areas of biological and two areas of physical science during four years of high school.

It is a fact that colleges do not require entering students in science to be well-grounded in science; but they do hope for a fair background

---

[4] President's Scientific Research Board, *Science and Public Policy*, Vol. IV, "Manpower for Research."

of general education with some idea of what special training is involved. It should be the function of the high school to educate, not only to train for a job.

All this does not preclude the possibility of presenting factual matter pertaining to the lives of plants and animals. The biology teacher, like every science teacher, is responsible for the teaching of facts and measurements on the one hand, and evaluation and judgment on the other. Nature study and classification activities should vary from one locale to another; yet there are some definite classroom and laboratory experiences that every pupil needs to help him shape his general approach to life. It is just as important for a pupil to know something of the laws of health and sanitation in a large city as on the farm; principles of inter-relationship of plants to plants, plants to animals, and of man to both is equally essential in both places; and sex education is needed as well in Indiana as it is in New York or California. An historical approach which considers the struggles of Pasteur, Jenner, and others, should aid the metropolitan and rural child to understand and appreciate better the importance of biology in everyday life. Concepts and basic principles, with their proximity to real, everyday problems make biology both cultural and utilitarian.

As a people becomes aware of its mistakes, it becomes willing to accept corrective legislation. Perhaps a man begins to practice soil conservation from a selfish viewpoint as he learns the benefits of such practices. Then gradually as the general populace gains awareness, the common good for all is recognized. Thus biology contributes not only to economic welfare, but also to human ideals.

Biology Teacher Training

Much change has been wrought, not only in the functional viewpoint, but in the philosophy of general education at the secondary level. Thus biology has as its dual purpose to provide some of the factual content of the former courses, and also, to teach the concepts, principles, and attitudes which are implied by both. This increased function of secondary school biological science at once presupposes that the instructor be broadly trained in as many as possible of at least the areas of biological science. His training need not be so specialized as that of a botanist, though he will need to be able to acquaint himself with the local flora of his area by means of a key, and to comprehend the importance of plant life; he will not be a specialist in entomology, anatomy, nor bacteriology, though he should have a speaking knowledge of each of these fields, and more; nor will he be a professional conservationist, forester, or health authority, though he have a general appreciation of the fundamentals of each. He must be brought to realize, somehow, the valuable contribu-

tion of these varied areas, with all they imply, to the general education of the non-scientist. On the other hand, he needs to serve as a living example of the true scientist, for the guidance of those who will become scientists.

Because it seems practically universal now to require major and minor areas with little or no provision for keeping them related, the prospective biology teacher may come out into the field licensed to teach also, English, social studies, Latin, or home economics, and so forth. In a survey to which 2,931 teachers of high school biology reported specific details of their training, it was found that 1,533 or 53% had prepared to teach biology and had majored in it in college; while 933 designated biology as a minor; 702 had special training to teach other sciences; 141 to teach social studies; 535 were trained in a wide variety of non-science subjects; and 618 stated that they had not prepared to teach biology![5]

There seems to be at present, not enough time for the college student to prepare himself to teach broadly in biology. He may have to keep biology classes, regardless of his major interests, but unless he is interested in the out-of-doors, and all it implies, he will not truly be a biology teacher. Studies by the committee of the American Union of Biological Sciences reveal the following facts: of 2,325 individuals replying to a question with respect to the general desirability of having more or fewer subject matter courses in teacher-training, 2,138 said more.

The colleges offer training of a specialized nature. Courses in general botany and general zoology are the initial offerings, following by genetics, entomology, bacteriology, anatomy, etc. These all provide a good background in their respective areas, far beyond what is actually needed for teaching in the high school; in fact, the beginning teacher has difficulty in bringing the subject matter of those areas which he has taken down to the adolescent level.

But requirements for graduation, patterns leading to graduate study, and licensing, added to the fact already mentioned, that one must prepare in two to four subjects to meet demands of employment, use up four years of college time too completely to allow for very adequate coverage of the biological areas. Each prospective teacher selects a few courses beyond the introductory courses as time and his own schedule permit. Each has some parts of a map, as it were, but the parts do not fit together in a pattern which gives complete or uniform directions.

This partly accounts for the unsettled high school biology curriculum, where one prospective teacher has taken courses of field and

[5] Union of American Biological Sciences, *Committee on the Teaching of Biology*, "The Teaching of Biology in Secondary Schools of the United States." 1942, p. 28

nature study content while another may have only laboratory courses. Especially, as it is frequent, if the college student has spent three, or nearly four years preparing to be a physician, a chemist, or a dietician, and then decides to teach, he is apt to have his course charted toward very specialized areas. And so, as he begins to teach high school biology, he finds himself unprepared either to meet pupil level or interest. It is strongly recommended that in such cases the example of the medical or law school be followed, namely, that certain courses are expected and no substitutes may be offered for them. (It seems, also, as logical that general zoology, physiology, etc., be taught for the future teacher as well as for the pre-medical student.)

On the other hand, if liberal arts schools and teacher's colleges could meet the challenge of the changing high school, an integrated pattern of two years of biology, with associated knowledge in chemistry, physics, astronomy, mathematics, and earth science woven into it might be established which would place the prospective teacher in the light of his future task. The resulting licenses would be biology and general science. Additional courses from one area would serve as training for a third license, and also as a stepping stone toward graduate work. A precedent in this direction has been set by some colleges, and some teacher licensing laws, as those of Indiana, tend toward such a pattern.

This college biology course, while at a somewhat higher level of detail and requirement than high school calibre, would provide the basic concepts and fundamental approaches to general education which is demanded for an effective handling of the high school pupil terminating his formal education. The professional education pattern for the teacher would include a methods course which embraces biological content of the secondary level. Every biology teacher would then know how to use a key to observe and name members of a given habitat; all would then know the significance of osmosis and photosynthesis; there would be some agreement as to what is important of health, genetics, conservation, and so forth; and principles which govern life and make for more efficient human living would be clear to every teacher who faces a class consisting of both general and college preparatory high school pupils.

It has been observed that a teacher begins to teach much as he was taught; and as he continues, he somewhat haphazardly adopts a pattern which is influenced by textbook authors (whose ideas also vary widely), by his particular experience and by chance contacts. Of course, a teacher must develop a philosophy which suits his own personality, and he will make contacts which differ from those of others; but if the start is of uniform quality that is generally accepted as a result of composite thinking and planning, there is bound to be less of

frustration on the part of both the high school biology teacher and his pupil.

Contributions of Biology

The contributions which biology can make, from the elementary grades through the first two years of high school, are enhanced by the fact that the materials required are simple and inexpensive. The poorest school, financially, can provide a rich program in the study of nature as it exists immediately at hand. In fact, the child's earliest concept of scientific study should be gained through the satisfaction that he can derive from doing in an approved manner that which he wants to do anyway—explore, investigate, watch, collect, and "try things."

If science instruction is begun in the primary grades, it is predominately concerned with biological materials though no attempt is made to call it biology. Gradually physical sciences are introduced, and as the pupil reaches upper elementary and junior high school levels, laboratory experiences are added. Biology reaches its capstone as the first individual science area in the ninth or tenth grade. After that, the typical high school curriculum makes provision only for physical sciences.

Because of its out-of-door flavor and, therefore, lack of the need for an expensive laboratory, biology may be taught with inadequate emphasis on the laboratory mode of learning. There should be a work room equipped with tables, cabinets, and shelves where pupils can store their collected materials, study them, and do simple experiments under controlled conditions. A minimum of equipment, most of which can be made from odds and ends, is needed; a few common compounds and reagents from the kitchen, the chemistry laboratory, or the drug store are sufficient. The set-up need not be elaborate in order to teach the high school student a method of observation and critical thinking or to foster the child's inherent curiosity in the world about him.

The importance of the strategic position of biology in the educational pattern for general purposes has been the chief concern here. The problems connected with this proposition are: (1) the place where biology fits into the all-science contribution to general education, (2) the approach to a dual responsibility of teaching scientific fact on one hand, and preparing pupils to judge and to evaluate clearly on the other, (3) the training of teachers to teach the subject so that it can perform both these functions, and (4) the intimation that biology can contribute to scientific attitudes and appreciations for both general education and special training.

What progress has been made? It is well recognized that science is

inescapably linked with the modern way of life. Numerous acts of legislation relating to sanitation, to isolation of certain communicable diseases, and to such phases of conservation of our natural resources as laws against stream pollution and requirements for instruction emphasize the fact that society does constantly increase its utilization of biological science.

We are still a long way from complete achievement. Man may conform, voluntarily or otherwise, to established mores; but without universal general education in terms of biological content, there will be a slow development toward desired goals.

SUMMER SCHOOL WORK FOR PHYSICS TEACHERS

High school physics teachers in eight states will be eligible for 50 all-expense fellowship awards in the third General Electric Science Fellowship Program at Case Institute of Technology in Cleveland, Ohio. The program will run from June 27 through August 5 and applications for the fellowships will be received until April 15, Dean Elmer Hutchisson of Case announces.

As in 1947 and 1948, special courses designed to bring the teachers information concerning the latest developments in physics will be conducted by the Case faculty in cooperation with the scientific staff of General Electric. Goal of the program is improvement of the teaching of high school physics courses. Emphasis will be placed on course contents rather than teaching methods.

Courses offered will include Basic Concepts in Physics, Frontier Problems in Physics, and Application of the Principles of Physics in the Control of Environment.

The fellowships will cover travelling expenses to and from Cleveland, living expenses during the session, tuition and fees. Teachers to whom the fellowships will be awarded will be selected on a competitive basis. Applications will be considered only from experienced teachers holding at least a bachelor's degree.

The fellowship awards at Case are open to science teachers from Ohio, West Virginia, Kentucky, Indiana, Illinois, Wisconsin, Michigan and Western Pennsylvania. Formal announcements will be mailed to secondary schools and to science teachers in the eight states. Application forms may also be obtained by writing directly to Dean Elmer Hutchisson, Case Institute of Technology, Cleveland.

A NEW FILM ON THE AIRLINE'S MEALS

A new 28-frame full-color slidefilm entitled "Mainliner Meals" has just been released by United Air Lines School and College Service.

The film, with an accompanying booklet, gives the complete story of the airline's meals, tracing their preparation from the planning stage to actual service aboard its planes. Approximately 3,000,000 meals were served to United passengers in 1948.

The film, of which one thousand prints were made, may be procured by schools, educators and other interested groups on a free-loan basis through the nearest United School and College Service office in Chicago, Los Angeles, San Francisco, Seattle and New York, or by contacting the nearest United Air Lines traffic office. Six other slidefilms, three 16mm movies, including colorful "Highway to Hawaii," picture sets, booklets, leaflets and outlines of suggested school and university courses also are available.

MATHEMATICS IN GENERAL EDUCATION[1]

RALEIGH SCHORLING
University of Michigan, Ann Arbor, Michigan

In my part of this forum I shall limit myself to an important phase of the problem of general education; namely, What mathematics should we teach to the large fraction of our high school population whose formal education stops at graduation or even before? A good answer to this question may contribute to a more productive and satisfying life for millions of our people in every generation, and is therefore of vital concern to the public welfare.

This sharp delimitation is desirable for three reasons: (1) the continued improvement of our institutions and the stability of our government is not fully guaranteed if we can not agree on what needs to be taught in citizenship, in science, in communication and in art to all future voters before they stop their schooling; (2) the identification of the content of general education may turn out to be a necessary first step, to dispel the confusion concerning the very meaning of general education now existing in the minds of even discerning writers at both the level of the high school and the college. For example, the Harvard Report, is, to say the least, not convincing in its proposals regarding the high school curriculum; (3) if we concentrate first on the "must" in the education for all citizens, certain recurring problems that now puzzle faculties in high schools and colleges are greatly simplified.

Let us list these questions as they apply to mathematical education in the high school. The first is: Shall we require one year of mathematics of all high school pupils? If the answer is "yes," many mathematics teachers will ask, Should it be one year of algebra or one year of general mathematics? Another question is, What is the content of a good course in general mathematics? Recently the editor of "Nation's School" requested me to formulate an answer for his magazine to this novel question: "Should all high school freshmen be required to take a course in arithmetic?" Shifting for the moment to science education in high school, the question might take this form: Shall we require one year of biological science? one year of physical science? or shall we require 2 years—one of which is biological science, and the other physical science? These crucial questions are now topics of endless debate in faculty meetings. Unless we can as a first step identify what we mean by competence in mathematics or competence in science as clearly as we now define functional literacy in reading, we shall con-

[1] Read before the Central Association of Science and Mathematics Teachers at Indianapolis, November 26, 1948. A part of the Third Annual Forum of the AAAS Cooperative Committee on the Teaching of Science and Mathematics, presented under the title "Problems of Science and Mathematics in General Education."

tinue to use the word "required" recklessly in descriptions of courses in high school and college.

On the other hand, if we can agree on what mathematics and science we want all students to learn before they leave school, such questions begin to be easier for we have at once two helpful criteria—*frequency and cruciality*—that we can use in determining the content of the required courses. For example we will surely teach the concept of *ratio* in high school mathematics, because most people will, time and again, make use of it in the common affairs of life, where the control of this concept makes an important difference to them.

Is it possible for us to agree on a short list of basic ideas and principles in mathematics for general education at the high school level? Fortunately our mathematics teachers have made an encouraging beginning. Recently the National Council of Teachers of Mathematics published a Guidance Pamphlet[2] written by the Commission on Post-War Plans. In that document there are identified 28 specific concepts and principles in mathematics that are considered essential in the education of all citizens. These are put in the form of questions in a check list for students. The list emerged from numerous conferences throughout the land and is, in fact, the product of many minds. A few illustrations of the basic concepts are: Can you use percents understandingly and accurately? Do you have a clear understanding of ratio? Before you perform a computation do you estimate the result for the purpose of checking your answer? Can you round numbers properly? Can you find correct values in tables? Can you read ordinary graphs? Do you know the mathematical guides that one should follow in collecting and interpreting data? These items will suffice to illustrate the simple nature of the content of mathematics in general education as it is now defined. It may turn out of course that this list will be reduced or increased by a few items. The important point is that we do have a tentative answer—we do have something definite that can easily be revised to meet changing needs.

Let us now consider once more some of the questions that puzzle mathematics teachers and note that such problems become easier when we approach them with the content of mathematics in general education for all high school pupils identified.

1. Shall we require algebra of all high school pupils? The answer now is an easy "no" for the reason that algebra as defined by widely used textbooks and by college entrance examinations, does not guarantee all of the desired competencies—not even to gifted pupils. Even if algebra did provide the opportunity to attain the 28 mathematical competencies for general education, so many of the specific

---

[2] "Guidance Pamphlet in Mathematics for High School Students," *The Mathematics Teacher*, December, 1947.

objectives for algebra lie outside the list that taking algebra would be a very expensive way for a student to get the mathematics needed in general education. Algebra as a tool of the scientist needs no defense. The door to algebra should be wide open, but no one should be pushed through it by requiring it for graduation from high school.

2. What is the content of a good course in general mathematics? The answer now is not too difficult for the 28 items for functional competence cited earlier, constitute the specific goals and therefore provide a neat and useful definition of general mathematics. Note that we are not especially concerned about applications for they may differ from community to community and obviously can be selected from a long list.

3. Shall we require arithmetic of all 9th graders? (You will recall that this is the question submitted by the editor of the "Nation's School.") The answer is clearly "no". If the pupils have been enrolled in a school that provides a strong offering in mathematics in grades 7 and 8, some students, as for example the future scientists, will achieve the desired competencies by the end of the 8th grade. Such beginning ninth graders will be mathematically mature enough to start the systematic study of algebra. Then too, if the students have been enrolled in a school that provides an obsolete offering in arithmetic, then the mathematical competencies for general education will not be attained in the first eight grades, nor would they be by offering another year of the same thing. During the last 30 years traditional arithmetic in grades 7 and 8 has been replaced in many schools by general mathematics and an additional year of general mathematics is offered as an elective in the ninth year in order to provide the mathematics needed in general education. As the level of general education is raised, the requirements in both reading and mathematics are increased. In great-grandfather's day a person could get along fairly well if he met a definition of literacy that required little more than reading and writing his name. And he got along somehow if he could do only a little figuring with whole numbers and common fractions, and knew a bit about decimals and per cents. But that won't do today. In World War II we were forced to redefine functional literacy to mean fourth grade achievement in reading. In like manner, more mathematics is required for personal use today than was needed in pioneer times.

4. Shall we require one year or two years of general mathematics of all high school students? The answer now to this question is obvious if the definition for the mathematics of general education is acceptable. A goodly number of 9th grade students can, under proper school conditions, achieve the desired competencies by the end of the 9th grade. The rest will need a third or even a fourth semester of general mathematics. The basic concepts in mathematics, although they may

seem absurdly simple to scholars are nevertheless enormously difficult to teach to all the children of all the people. As regards the proposal of a second year of general mathematics, it is amazing to note that in a sample of high school youngsters—more than 300,000—taken last year, 1 out of 16 pupils in the tenth grade was enrolled in a second year of general mathematics in spite of the fact that to date there is not a single textbook available specifically designed to service that course!

5. What is the main shortage in teacher education for this job of providing the mathematics in general education at the high school level? The answer to this question is suggested by the strong tendency for the general courses to become stigmatized. An unpublished dissertation which the Cooperative Committee on the Teaching of Science and Mathematics has carefully considered, provides convincing evidence that this is true even in the case of science courses designed for general education in college. Far too often teachers are by training disposed to give a halo of prestige to the older, traditional, sequential courses. This attitude may be due in part to the fact that many of our high school teachers have never had a single course in mathematics for general education either in high school or in college. For example, I have at present a course in the teaching of mathematics at the University of Michigan in which 33 students are enrolled. Of these only 3 have ever had a course in general mathematics. In all probability these beginning teachers will take mathematics positions next year in high schools that will require them to teach more courses in general mathematics than traditional sequential courses. We are selecting our prospective teachers in mathematics from persons who are adept at symbolism, and from those who have travelled the route of the traditional mathematics courses in high school and in college. The content and procedures in the general courses are quite different, and unless the prospective teacher has experienced them, he will have difficulty in teaching the newer courses with zeal. Moreover, such teachers do not make clear to students and parents that both types of courses, the general and the sequential, are worthwhile for the pupils who need them, and that they offer different experiences for pupils with very different needs. Then too, such teachers are likely to approach the problem of guidance and homogeneous grouping by classifying pupils on the basis of intelligence tests alone and they will thus fail, as was suggested earlier, to utilize the different objectives of the two courses as an important factor in classification.

The program in teacher education in science and mathematics needs to recognize the importance of the general courses. We need to reject the fallacy that there is a conflict between general education

and the rigorous training of the future scientist. We are not dealing with an either/or proposition. Both tasks must be done, and done extremely well in the high school years. Every department of science and mathematics should include one or more teachers who see clearly the function of the general courses and who are disposed to teach these courses with evangelical zeal. A practical suggestion to correct the main shortage in teacher education has been proposed by the Cooperative Committee on the Teaching of Science and Mathematics in Volume 4 of the Report of the President's Scientific Research Board. This report points out that the education of teachers in science and mathematics in many training institutions is unrealistic and lists the following five limitations: "(a) Too many courses are, in fact, designed to select and train specialists in science and mathematics (p. 102). (b) Too often prospective teachers of science and mathematics for the lower schools are not trained in broad areas that will enable them to do a good job teaching several subjects in the early years of teaching in small high schools (p. 103). (c) In general, colleges and universities fail to provide a year of professionalized subject matter especially designed to meet the needs of our teachers (p. 105). (d) In science and mathematics, conventional undergraduate courses provide good background for the traditional high school courses, but do not provide adequately for the new courses that are emerging to meet the general-education needs of pupils or for the close correlation of science and mathematics which is needed in the education of talented science students (p. 106)." The report of the Cooperative Committee further recommends that the undergraduate training program for teachers of science and mathematics be a specifically planned professionalized program. Significant is the following comment: "While the present sequence of science courses may be very satisfactory in the selection and training of future science specialists, and not too bad as a training program for teachers in large high schools, they fail to give breadth of understanding or comprehension of the interrelationships existing between the many specialized fields of science and mathematics. These understandings and relationships are essential for teachers in the secondary school, where they must, at best, teach in broad areas (p. 103).[3] A fifth year of college training for high school teachers is clearly indicated. However, merely adding another year of the same type will not meet the needs of persons who begin their teaching in small high schools."

The sixth question: Is a double-track—one for the mathematics in general education and one consisting of rigorous sequential courses for future scientists—possible in the small high school? By a small

[3] Science and Public Policy, Volume 4. A report to the President by the President's Scientific Research Board, Oct. 11, 1947.

high school we mean one with fewer than 200 students, and probably fewer than 8 teachers. This definition includes about ⅔ of all high schools. As many people realize the offering in science and mathematics in a small high school is pathetically meager. In many small schools the offering in science and mathematics is limited to the traditional sequential courses designed for college preparation, in spite of the fact that a very small fraction of the graduates ever enter college. On the other hand, some small high schools offer only the general courses in science and mathematics and still others provide no science and mathematics at all in a particular grade. But this regretable situation need not continue. The Cooperative Committee has made three suggestions, of which only the following will be cited here. "The small school can enrich its offerings by teaching simultaneously in small classes of perhaps only a half a dozen students two courses on different levels—one on the level of general education, and one providing a rigorous course for the future science specialist." Thus we see that the answer to our question is "yes,"—in fact, there are discerning persons who believe that the double track is more easily provided in a small class of 9th grade mathematics when taught by a resourceful teacher than it is in a large junior high school.

This discussion can be summarized by three statements: (1) An important—perhaps a first—step when attacking the broad problem of science and mathematics in general education is to identify the specific concepts and principles in mathematics and science that need to be taught to students in high school whose formal education stops very early in life. (2) If we were agreed on the science content for better living for all our people, then the solutions to some basic problems in general education that often confront high school faculties would probably evolve as easily as do corollaries in geometry. (3) In general education, we are not primarily concerned with vocational goals—important as these are—rather we seek to promote the public welfare and especially the growth of the student as a person as regards reasonable competence in quantitative thinking in every day affairs, the disposition to use critical thinking, and the reading of the public press with discriminating intelligence.

CAPTURING SUNLIGHT

Only about half of one per cent of the year's sunlight falling on a plot of land is captured by a bumper corn crop—one of the most efficient photosynthesizers. Theoretically almost 10 per cent of the energy of light actually absorbed in a growing plant can be stored as chemical energy. The scientists' problem is to learn to duplicate the process of photosynthesis and to increase the efficiency of the process.

—FARRINGTON DANIELS

WHY STUDY MATHEMATICS?

BJARNE R. ULLSVIK
Illinois State Normal University, Normal, Illinois

If you are a sincere young person, you will ask some questions as you begin to study this first year course in high school mathematics. Some of these questions may be—What benefit or good may I expect from the study of mathematics? What am I expected to know in order to begin? How can I learn more easily the new ideas presented?

Let's take these questions one at a time.

What Benefits Or Good May I Expect from the Study of Mathematics? The purpose for the study of mathematics is much the same as that of other high school courses. All have one common objective—*To learn how to live effectively in our democratic society.* No course can fully teach this, but each makes a contribution. The special contribution of mathematics is concerned with problem solving—not so much with the answer, but in the methods used. Although the answers to several problems may be different, the methods of solution may be much alike. Do you believe the answer is more important than the method? In some cases one must admit the answer is more important, but a method is necessary to arrive at an answer. He who knows of a method is in command.

You will find this beginning course in algebra concerned with methods of problem solving, and if you thoughtfully take part in the class activities your methods will be greatly enlarged. The methods you know are those you learned in arithmetic. They are good, but more powerful methods are necessary to solve problems of modern youth. The problems facing you are, and will be, different from those met by your parents and grandparents; yours is a different world.

Mathematics has been somewhat responsible for this change, for many of the new inventions and ideas are essentially the products of mathematical thinking. To understand how these new products were developed will require more mathematics than presented in algebra, but you will learn what is basic to such understanding. The automobile, radio, television, calculating machines, and hundreds of other inventions are essentially mathematical machines. You need not know the mathematics involved in their construction to operate, appreciate, and enjoy them, for you are purchasing the mathematical knowledge of others as applied in your behalf. To operate, one needs to know the "how"; but to create, one needs to know the "why." Those who create the construction of the machines have used their mathe-

matics, so only a minimum of mathematics is necessary for the operation. A push on the automobile accelerator, a turn of the knob on the radio, or dialing a number on the telephone will set in operation the mathematical design previously determined. Although knowledge of the "how" will often put the mathematics in operation, our country needs those who know the "why" if we are to keep our leadership in science. Are you interested in helping keep this leadership? If you are, then you are concerned about the "why"; and you are concerned about mathematics. With such concern you will find algebra a real challenge along with much fun.

Which would you prefer to over-haul the motor of your automobile or repair your television set—a mechanic who knows the "how," or one who knows both the "how" and the "why"? If a surgeon were to perform a major operation on you, which would you choose—one who knows the "how," or one who knows both the "how" and the "why"? Likewise a druggist to fill a prescription for you? What kind of a dentist to pull an aching tooth? An engineer to build a bridge over a deep and scenic canyon? Because you want to "live and let live," all of you will make the same choice between these two kinds of skilled persons.

There are many unanswered "why" questions in each vocation, and those who continually search for such answers are the more skilled. The more "why" questions a skilled person can answer, the more he can direct others and create new ideas. If you have such ambitions, you had better learn both the "how" and the "why." Algebra can provide such opportunity, for almost all the sciences use the language of algebra. Do you want to keep this path open? If you do not care to try, then the thrill of science will not be yours. A word to the wise—leave all paths open as long as you can, then you will not regret having closed them.

Few, if any of you, know what will be your occupation. In fact, many adults do not have but a single occupation, for they have found it necessary to change from their chosen ambition. Some changes have been necessary because of physical disability, change of residence, or financial loss; or, in many cases, unforeseen events caused a decrease in the profit and service of an occupation. About 50 years ago some young men were preparing to become blacksmiths. Perhaps you have never seen a blacksmith. That indicates the lack of good sense in making preparations for a single occupation. Only a short time ago the silk industry gave much promise, but the invention of nylon has largely destroyed the big market in silk stockings. It is possible that some of today's occupations may not be profitable when you become an adult. But you can be sure mathematics will continue to be important in many profitable occupations

long after you have become an adult. Don't place all your eggs in one basket.

Because it is difficult to think of a single occupation that does not use some mathematics, many paths are open if you have a basic knowledge of mathematics. Of course, some occupations do not require more mathematics than the arithmetic you learned in the eighth grade. But do you know this arithmetic? Many soldiers in the last war were required to take a test in arithmetic, and they were found to be "rusty." Some could not add fractions nor multiply decimals, and some were not able to get the correct sum of a column of numbers. Would you stake your life on such knowledge of arithmetic? Perhaps you remember your arithmetic well enough to apply for many adult occupations, but will you know it well enough when you need it on the job? In order to maintain your understanding and skills in arithmetic, you will need an occasional good "brush up." This practice will not only maintain and increase your understanding of arithmetic, but you will be better prepared for further study of mathematics, science, and the skills required in hundreds of occupations.

But you expect to do more than practice the arithmetic you learned in eighth grade—and you will. If you have ambition to become an engineer, a scientist, an accountant, a teacher of mathematics, a nurse, a pharmacist, or some other skilled person whose education requires some professional training beyond high school, you will need much more mathematics than eighth grade arithmetic. This beginning course in algebra will present you with mathematics basic to success in these professions, but you will want to take additional courses in high school mathematics. *If you do not learn more mathematics than arithmetic, you are closing the paths of opportunity to hundreds of occupations.*

Do you recall the fable of Chicken-Little? She believed the world was falling upon her, and she convinced her other animal friends in believing the same. Some people behave in much the same manner, for they seek answers from others rather than think for themselves. Of course we must use the help of experts, for many problems are so complex that we must depend upon more experienced people to help direct our efforts. But thinking people demand all persons—even experts—to present facts to justify their conclusions. That makes us more democratic. Thinking people, or citizens of a democracy, are not like the animals in the "Chicken" story, for they accepted conclusions without further question. Thinking people don't act that way. They are more self-reliant.

You want to become more self-reliant, and mathematics can help you. Learning to solve problems rather than accepting the given

answer is a first step. We can't become completely self-reliant, for we depend upon skilled persons to help us. Such services may not be necessary for our existence, but they are necessary for our mode of living. What our parents considered as luxuries have become necessities—at least we don't want to be without them. The automobile was a luxury for your grandparents, but for many persons it has become a necessity. The services of a physician, a dentist, an auto mechanic, a radio repairman, and other similar specialists may not be necessary, but we consider them conveniently essential. Yet, we can become self-reliant in purchasing their services. Finding the kind of specialist to perform the kind of service in the manner we desire is acting as a self-reliant consumer. This is especially important in our democracy, for such consumers help maintain honest and efficient service. Can mathematics help here? Indeed it can, but more than algebra is necessary. Algebra can serve as the foundation for geometry, which is a subject where you can learn much about using the thinking of mathematics in social situations. The study of geometry can make you self-reliant by learning of conclusions that must follow from the facts one accepts.

Do you know our world is shrinking? This is no fairy story. It is not smaller in terms of land structure, but in the time required to reach distant places. The people your parents and grandparents considered as foreigners must now be considered as neighbors, for their lives affect us. We live in a one-world, whether we like it or not. Additional problems are facing you, because you live in this smaller world. Peace on earth and good will toward men depends upon honest persons who are able to solve these problems. Mathematics has done much to produce this smaller world, and mathematics can do much to teach us to live peaceably in it.

If America intends to contribute to the solution of problems affecting our nation, a young America must be ready with effective methods. You may not actually use the methods, but as an American citizen you will cast judgement upon the methods of solution adopted by our leaders. Thinking results in intelligent action, and in a democracy this means to vote according to what our powers of reason dictate. One's reasoning depends largely upon what facts are available, unless gossip and rumor blind one to viewing the facts. To be practical, one must consider the effect of gossip and rumor, but they must be classed among the superstitions. They are unscientific, and good thinking cannot take place in their presence. If some new information is presented to you, can you judge its worth? Can you apply good thinking in judging the information by eliminating your own opinions? Do you know how to search for opinions expressed in the new information? If you cannot, then you may be misled in be-

lieving what some one wants you to believe. No thoughtful citizen wants to be misled. He wants to think for himself and draw his own conclusions. "If you fool me once, shame on you. If you fool me twice, shame on me."

In short, mathematics can make you a better citizen, thereby helping to preserve our democratic way of life. Is there a better reason for your attendance in school? Americans believe not.

Now let's consider the second question—*What am I expected to know to begin algebra?*

You will be surprised how little knowledge of mathematics you really need. Your teacher has anticipated some of your gaps, and you will find practice exercises even for those who have difficulty in adding up a column of numbers. Few, if any of you, will need such practice, but it is necessary to make sure you know arithmetic. Some of you may need to work a bit harder to make up for some of your difficulties. If you have the desire to do so, you will be given every chance to succeed. Those of you who indicate a good understanding of arithmetic will not be asked to perform the assignments set up for those who have difficulty with the fundamentals. The better you understand arithmetic, the more easily you will read the material prepared for this course; the less well, the more effort you must display to place yourself on equal footing with your fellows.

Can you read? You may think it silly to ask such a question of a beginning high school student. Your teacher will not. Can you answer "yes," if the question is changed to, "Can you read the language of mathematics?" You must confess you do not know what is meant by the "language of mathematics." Yet, the language of mathematics will continue to have more effect upon your life than any other language. The nations of the world will use their own language to describe the terrifying effects of the atomic bomb, but the scientists will use the language of mathematics to explain the "how" and the "why" of this tremendous discovery. You can't say "hello" in the language of mathematics, but its use has enabled the world to say "goodbye" to itself.

Lancelot Hogben wrote an interesting book entitled, *Mathematics for the Million*, and he distinguishes between two languages—the language of sorts and the language of size. By language of size Mr. Hogben means the language of number ideas. When you understand the meaning of "number ideas," you will learn the power in the use of the language of mathematics. Just as there is a vocabulary to master in learning any language, you will be asked to learn some new words to think in the language of algebra. All the words of algebra will not be new to you, but their meaning will be different. Words such as "radical," "root," "similar," "square," and others

will be pronounced the same, but their meaning will be that agreed upon by the mathematicians.

As you learn these new meanings, you will find the language of mathematics not more difficult than the "language of sorts," which you have become accustomed to using. This new language will enable you to express ideas more clearly—especially those ideas concerning numbers. While the "language of sorts" tends to hide these number ideas, the language of mathematics places focus upon the frame-work of ideas. To understand and use this language will be one of the major goals of algebra. When you have learned it, the kinds of problems you can solve will greatly increase. Problems which were impossible by arithmetic will seem easy when you apply the language of mathematics.

You have now been informed that a knowledge of arithmetic (some gaps being expected) and an ability to read are necessary to begin algebra. Yet an important quality for success has been only slightly mentioned. You guessed it—*A Desire to Learn.* It is most important, for without it your abilities will become "rusty." A desire to learn can often overcome a disadvantage, but without such desire the disadvantages or gaps make for an unhappy experience in learning mathematics. If you have had such an experience, do you want a repeat performance? Neither does your teacher.

The third question—*How can I more easily learn the new ideas presented?* Because you may desire some suggestions, the following "ten commandments" for effective study of mathematics are given:

1. Because mathematics is a system of thinking rather than a method of moving numbers around, it is necessary to have an orderly development of the new ideas. You really grasp the power of mathematics when you learn the order of thinking as well as the ideas developed.

2. In solving a problem give careful attention to what you are given and the kind of solution required. What you have to work with, and work for, will often determine the method you will use in finding the desired solution.

3. Read carefully! Will you be the kind of student who senses how to solve a problem only when the teacher asks him to read it aloud? Most teachers have had such experience with students who read carefully only when requested to do so. Don't let this happen to you!

4. The problems which you will be asked to solve are those which you may find in the newspapers, magazines, or on the radio, or those begun by class discussion. They are only samples of the kinds of problems you may need to solve as an adult. Mathematics is found all about you—not merely within the mathematics classroom or in the material given to you. Search for uses of mathematics in your

daily living, and there will be little need for your teacher to make mathematics more life-like.

5. Learning, at its best, takes place when the student discovers, rather than follows the assigned activities. When you can work for yourself rather than for the teacher, then your learning will stay with you. Your teacher will try to permit you to sense the discovery of each new idea. Without your cooperation such teaching is not possible.

6. Do not be satisfied with finding only the answer. The method of solution is really more important, for you may not use the answer again, but you will doubtlessly again make use of the method. Your success in algebra is measured more by the kind of method you use than by the kind of answer you find.

7. A fellow student may be of real help in a cooperative working arrangement—only if he doesn't serve as a substitute for your thinking. You can be aided in learning what to discover, but you must take part if you want to remember what you have discovered together. Don't use a fellow student as a crutch, for you may not have this crutch when you must stand on your own feet.

8. Answers to some problems may be given to you. They can be of help, if they are used to save time in learning of the correct answer to check your work. If the answers are used to decide upon the method to arrive at the answer given, if will be better not to have the answers available. Don't be tempted in trying to fool yourself! Effective classroom learning demands faith in each other.

9. When you are preparing to study mathematics have all necessary equipment at hand. This may include a well sharpened pencil, or a smooth functioning mechanical pencil, an eraser, enough paper, and at times a protractor, compasses, and ruler. If you have all this equipment available, you will not bother your neighbor by borrowing his materials.

10. No book, school, course, or teacher ever gave anyone an education; they only provided an opportunity. This course in algebra will merely aid your teacher in providing you with an opportunity to learn some basic mathematics. School provides a short-cut to important learnings, but it will not provide for understanding—that you must do for yourself.

RUBBER STREETS

Street pavings of asphalt, containing a small amount of powdered rubber, are to be tested in several states this year. European experiments show that this mixture has several advantages, including longer life for the road.

THE COMMUNITY

A TEACHING UNIT IN ECOLOGY

JOHN P. WESSEL AND PAUL A. MEGLITSCH
Chicago City Junior College, Herzl Branch

Plants and animals are not distributed as they are over the surface of the earth by chance, but because of a combination of circumstances, one of which is the fitness of the physical environment for the completion of their life histories. The mutual suitability of the organism and its environment is not itself a matter of chance. Both are changing slowly. The earth has undergone a geological evolution which has not yet ceased. Some coastal areas are still slowly rising or falling and mountain ranges are being leveled off by the gradual processes of erosion. In the past, prolonged climatic changes, like those concerned in the ice ages, have had their part in modifying conditions on the earth's surface. Plants and animals are rarely, if ever, perfectly suited to their environment. Whenever a population is not perfectly suited to its environment, individual variations already present within the population and new mutations which are constantly appearing provide the materials upon which natural selection can act. As those members of the population which lack the potentialities necessary for life under the prevailing conditions are gradually weeded out, and new combinations of characteristics which are more successful appear, the character of the population slowly changes. Generally the changes which occur in the evolving population have "adaptive value," that is, they are of such a nature that they increase the number of successful offspring which an organism can produce. Adaptive changes are called "adaptations," and an organism which is well adjusted to the environment in which it lives is said to be well adapted. Many adaptations which are found in plants and animals are particularly suited to life in some special region. Because of the evolutionary mechanisms involved, this relationship is to be expected. The slow, inexorable forces of natural selection operating in a desert or in the arctic regions, for example, ensure that the species which survive will exhibit the characteristics necessary for life in that region. Species which fail to develop the necessary modifications decline and become extinct, to be replaced by other forms.

It is helpful to bear in mind the close relationship between Ecology and Evolution. We can see its results in the form of adaptations which fit organisms for life in the regions which they occupy. For example, animals found in the tropics have different kinds of adaptations from those found in arctic regions. The *light* and *temperature* factors differ greatly in these two communities. The characteristic

UNIVERSITY OF MICHIGAN LIBRARIES

fur and fat which insulate the polar bear are adaptations suitable to arctic but not to tropic life. Likewise, the *water* requirements for life in a desert are different from those for life in a deciduous forest. Adaptations resulting in negative phototactic behavior, low rate of water-loss, special water-storing tissues, and a low water economy have survival value for the desert organisms. The gleaming winter whiteness of the ermine becomes a more subdued brown in summer, in response to a changing metabolic rate induced by temperature changes. Such an adaptation would have no value for an animal in the tropics or desert where the *substratum* is at no time of the year covered with snow. The medium on which or in which organisms live such as the earth, water, air, or bodies of other organisms, shall be referred to as the substratum. The nature of the soil influences the character of the plant population, and the types of animals which can maintain themselves upon it. The type of soil, whether sand loam, or clay, often has a considerable influence on the ability of organisms to live in or on it. Animals possess many structural adaptations to their substratum—the streamlined form of fish, seals, and wales; the wings of insects, birds, and bats; the large shovel-like feet of moles; the long legs of wading birds; the spines, hooks, and suckers of parasitic flatworms that enable them to cling to the viscera of their hosts; the sharp claws of squirrels and other arboreal animals—these are but a few of the numerous successful adaptations to a variety of types of substratum. While it is true that most organisms have become structurally adapted to their substratum, some forms have changed the substratum to fit themselves. The nests of birds, the elaborate tunnels and galleries of termites, and the tubes of many marine annelids illustrate this ability. The substratum before or after modification, often provides shelter for the animal against rain, cold, or intense heat, and a place to hide from enemies. Man, especially, has utilized his substratum. He has moulded parts of the substratum into ships and airplanes, fitting himself for life on the water and in the air. He has greatly enriched his life on the earth by the construction of automobiles, bridges, tunnels, streets, buildings, and household comforts.

Most organisms are limited in their distribution. When the presence or absence of some factors, physical or biotic, determines the presence or absence of a certain organism, this factor may be called the *limiting factor* for this organism. This is the "principle of limited distribution of organisms."

Algae require light to carry on photosynthesis. They are most abundant at the surface of the sea. There is a population gradient that is lowest at about 600 feet below the surface, where less than 0.1 per cent of the light penetrates. Since carbon dioxide, water and

salts are present in abundance below this point, *light* is obviously the most important limiting factor. Animals which depend upon these plants for food are also absent at depths below 600 feet. Here only carnivores and scavengers live.

The polar bear is found along the margin of ice floes in the north. Ice floes are limited to regions in which the temperature averages no higher than 32° F. *Ice floes*, directly, and *temperature*, indirectly, are therefore limiting factors in the distribution of the polar bear.

The scarcity of water in a desert limits the community to those organisms having adaptations resulting in a low rate of water-loss, special water-storing tissues or a low water economy. *Water* becomes a limiting factor to desert life.

The presence or absence of specific chemicals may determine whether a plant or an animal can live in a community. Carbonate of lime is necessary for the construction of the shells of certain snails. These species cannot live where there is an insufficient supply of this chemical. Thus, the *chemical*, carbonate of lime, becomes a limiting factor in the distribution of certain snails.

Along certain regions of the Pacific coast clumps of large brown algae form "algae islands". Between these islands the water is completely devoid of algae. This peculiar distribution is due to the presence or absence of rock at the bottom. The algae have long stalks, terminating in holdfasts which cling to the rocks at the bottom. *Rock* in the substratum is the limiting factor in the distribution of the algae.

The fitness of the physical environment for the completion of their life histories is not the only factor governing the distribution of plants and animals in more or less well defined communities over the surface of the earth. The presence of other organisms is also an important factor. Although we sometimes refer to organisms as being solitary, gregarious, or social, no organism lives alone. Every organism shares its evnironment with others of its kind and of different kinds and in consequence is compelled to participate in the struggle for existence in which the fittest survive, competing for space, food shelter, and mates, and exposed to the depredations of enemies. The intense struggle between members of a community, fostered and maintained by their reproductive capacity, always potentially greater than the substratum can bear, has existed for millions of years. The complex and intricate interrelationships which have developed, often referred to as the *"web of life,"* defy a satisfactory analysis. We shall attempt to analyze but a few of the threads of this web.

The *Struggle for Energy*. Food is fuel. Fuel is a source of energy. The energy necessary for carrying out the business of living comes

UNIVERSITY OF MICHIGAN LIBRARIES

from food. When plants synthesize food they do not manufacture energy. Energy from the sun's rays is imprisoned within certain complex organic molecules—stored in the form of food. The struggle for energy among green plants is largely a struggle for a *place in the sun*. They also compete, to a lesser degree, for the other raw materials needed for food synthesis: *water*, *soil*, *minerals*, and *carbon dioxide*.

While photosynthetic plants compete for the same things, the diversity of food habits among animals leads to a variety of forms of competition. Since animals do not manufacture food from inorganic raw materials, and cannot capture energy from the sun, the struggle for energy is not for a place in the sun but for the bodies of plants and other animals. Ultimately all animals are directly or indirectly dependent upon plants for their source of energy, but since the animal body also represents stored-up energy or food, there are two immediate sources of food for animals. Some animals obtain energy by eating plants. These forms are called *herbivores*. The herbivores may be as small as a protozoan or as large as an elephant. Difference in size reduces competition among herbivores for they utilize different sources of plant food. Animals which eat other animal are called *carnivores*. Animals which eat plant and animal materials are called *omnivores*. Larger carnivores eat smaller carnivores. Some of the larger carnivores, like the polar bear, have no enemies in the sense that they are not captured for food by any form. They have the lowest reproductive capacity. The plants which cannot carry on photosynthesis join the animals in their dependence upon green plants for food. Many bacteria and fungi are organisms of decay, attacking dead or moribund plants and animals. Others live as parasites, commensals, or symbionts. Either plant or animal may serve as hosts for the colorless plants. A great many plants, herbivores, carnivores, and omnivores are intimately linked together by their food requirements. Such a food relationship is commonly called a *food-chain* or *food-web*. In any food-chain the number of plants is larger than the number of herbivores, the number of herbivores is larger than the number of small carnivores; and the number of small carnivores is larger than the number of large carnivores. This quantitative aspect of a food-chain is referred to as a *pyramid of numbers*.

As in the case of the physical environment, the biotic environment also affects the distribution of organisms. Thus, since the caterpillar of the cabbage butterfly, *Pieris rapae*, feeds exclusively on the leaves of cruciferous plants, the presence of these plants becomes a limiting factor in the distribution of the cabbage butterfly. The presence of sheep and even more specifically of certain snails serves as limiting factors in the distribution of the sheep liver fluke which parasitizes

the sheep as its definitive host and the snail as its intermediate host.

We see, therefore, that the environment, both physical and biotic, influences the organisms living within it in two ways. (1) it requires of these organisms certain potentialities which enable them to compete successfully in the given set of environmental conditions, and (2) it determines the geographical distribution of these organisms.

Plant and animal interrelationships. There exist in every community a great many close interrelationships between plant and plant, plant and animal, and animal and animal. These interrelationships add further to the complexity of the community and are integral parts of the "web of life." These biotic interrelationships may be divided into two categories: intraspecific and interspecific.

Intraspecific interrelationships. The intraspecific interrelationships are those which exist *within* a given species, i.e., between the members of that species. Most commonly these interrelationships express themselves in the form of *aggregations for mutual aid,* as instances of intraspecific cannibalism are exceedingly rare. Such aggregations may exist for the following benefits:

For food: Thus, packs of wolves hunting together can stalk their prey and attack it with greater efficiency than through individual effort.

For protection: The musk-ox of the Artic regions of North America herds together for defense against the Artic wolf. When wolves attack the herd, the largest and strongest bulls form a ring around it, thus facing the predators and ready to defend the cows and calves within the ring.

For migration: Birds migrate in flocks, with the older, more experienced members of the flock alternating as leaders.

For regulation of body temperature: Sheep in winter cuddle together to prevent the rapid dissipation of their body heat. Likewise, bees get together in thick masses during the winter for more effective insulation against the cold.

For hibernation: Rattlesnakes (genus *Crotalus*) gather in the late autumn in a well-protected recess in the rocks or under the roots of a fallen tree and spend the winter together in hibernation. Several hundred individuals in family units may assemble in this fashion. The specific benefit derived from this aggregation by each member of the hibernation colony is not apparent.

For efficient social organization and division of labor: Bees, ants and social wasps belong to this category.

Intraspecific interrelationships generally provide some degree of *harmony* within the group. There exists, therefore, a kind of *cooperation* between the individuals of the group, resulting in aggregates which possess survival value. The ability to survive then is not al-

UNIVERSITY OF MICHIGAN LIBRARIES

ways only a matter of the "struggle for existence" between individuals but may also depend on the kind of aggregation of which the individual is a member. This concept is sometimes referred to as the "*principle of cooperation.*"

Interspecific interrelationships: Interspecific interrelationships, i.e., interrelationships between members of different, often distantly related species, constitute, beside food-chains, also relationships known as *saprophytism, symbiosis, parasitism,* and *commensalism.* These associations increase the adaptive efficiency of a community and thus enable the substratum to support a larger population.

Saprophytes are plants which obtain their food from the dead bodies of plants and animals or their waste products. Saprophytism is responsible for most of the decomposition of organic products produced by animals and green plants in food synthesis and assimilation. The accumulation of dead plant and animal material would convert the earth into a vast cemetery, with carbon and nitrogen unavailable for the use of living organisms, were it not for the saprophytic organisms. Decay and putrefaction are vital processes in the "web of life."

The living bodies of plants and animals are also utilized as a habitat thus further diversifying the community. Such organisms may be *parasitic,* harming their hosts; commensal, causing no appreciable damage to their hosts; or symbiotic, living with their hosts to the mutual advantage of both forms.

The Principal Biotic Formations: Those who have traveled extensively throughout the length and breadth of the North American continent readily recognize that the continent consists mainly of some half dozen different "kinds of country." The layman refers to these *large natural formations* as forests, prairies, desert, sagebrush country, the far north, and the tropics. Indeed, with but slight modification, these terms are used by the ecologist. Each formation, or *biome,* is the product of a specific combination of physical factors, such as the nature of the substratum, the amount and frequency of rainfall, and the annual distribution and intensity of light and temperature. These physical factors and others determine to a large degree the kind of flora and fauna characteristic of the formation.

The tundra formation (*sedge-musk ox biome*): This is the region that extends from the northern limit of trees to the polar region of perpetual snow and ice. Those areas above the timber line on high mountains, where climatic conditions are similar to those of the far north, are also included in this biome. One need not necessarily travel to the far north to study the characteristics of a tundra community; he need but climb any one of the many high mountains characteristic of the western regions of the United States. The tundra is treeless, and in the short summer of about nine weeks, the ground is partially

covered by low plants, mainly bog mosses, lichens, while ponds, marshes, and bogs are numerous; drainage is poor, and only the surface soil thaws out during the brief summer. All of the birds are ground nesters. The principal resident birds are the snow grouse (ptarmigan) and the snowy owl. There are many shore birds and waterfowl that spend only the summer in the tundra. No reptiles have been found. The principal mammals are the musk ox, the caribou, arctic wolf, weasel, arctic hare, and lemming. Some of these mammals are adapted to the climatic rhythms of their environment by changing in color from white in winter to a darker color during the summer.

Since the land offers but scant food, many tundra animals are limited in their distribution to the margin of the Polar Sea and its numerous bays. Thus, the polar bear, the seal and the walrus roam the icy, desolate wastes of the seashore or the ice floes feeding upon the rich and varied fish fauna of the Polar Sea. They are dependent, however, on the land for they cannot breed in the water. The whales, on the other hand, are exclusively marine.

Any ecological analysis of the tundra must consider the Eskimo an influent animal. He has few demands to make of the outside world. His requirements in clothing, food, and home are wrested from the tundra in his own struggle to survive.

The tundra is interesting because it is in a state of natural equilibrium. Trappers do kill wolves, foxes, and caribou; and the musk ox has been captured for museums and zoos. However, the severity of the winters and comparative inaccessibility of the tundra have reduced the activity of non-native man to a minimum. He has not noticeably affected the balance of nature in this region.

The coniferous forest formation (*spruce-moose biome*); This formation extends south of the tundra to northern United States (including the north woods of Minnesota, Wisconsin, Michigan, and Maine) with extensions southward along the mountain systems (Sierra-Cascade, Rocky, and Appalachian) to central Mexico. The winters are not quite so long or cold as in the tundra; the summers are cool; rainfall is moderate. The characteristic trees bear cones; and, since they shed their needle-like leaves throughout the year, there is no time when the trees are bare. The tall slender trunks and characteristic branching give a distinctive physiognomy to the biome.

The principal animals in the coniferous biome are the moose, grizzly bear, elk, deer, beaver, porcupine, mountain sheep, mountain goat, snow shoe rabbit, jay, and crossbill. Mites, beetles, and ants are among the characteristic arthropods.

Following a forest fire, aspens appear, which, however, are in time replaced by the conifers. In the (mountain) coniferous forest the

UNIVERSITY OF MICHIGAN LIBRARIES

aspens are considered a fire indicator; that is, the area covered by aspens was formerly burned over.

The deciduous forest formation (*oak-deer biome*): The greater part of the United States east of the Mississippi River is characterized by deciduous forest. In the north part of this biome the winters are cold; summers are warm, with rain, and a relatively high humidity.

Some areas in the deciduous forest are pure oak and hickory; other sections are beech and maple; others are oak and chestnut. These areas are called *associations* of the deciduous forest biome. This biome is characterized by trees that lose their leaves annually. The trees all have spreading branches; the leaves are present five or six months, but during the remainder of the year the limbs are bare. The forest floor is covered with herbs, sometimes quite dense, and frequently growing to a considerable height. The Virginia deer, the black bear, opossum, raccoon, grey fox, black snake, grey squirrel, wild turkey, and woodpecker are among the most characteristic animals.

The grassland formation (*grass-bison biome*): This biome is sometimes referred to as the Great Plains or simply as the prairies. It extends from the Mississippi Valley westward to the mountains, and from Texas north to Canada. Winters are cold, summers hot, and the rainfall includes numerous thunder-showers. There is a general scarcity of trees and those that exist are found mainly along streams. The principal plants are grasses (bluestem, grama, and buffalo).

A trip through Oklahoma, through the pan-handle of Texas and through eastern New Mexico would take us across the grassland biome. Pioneer settlers say that fifty years ago this was beautiful grassland. One can be sure that this is so, if he examines cemeteries where, the area having been fenced in from grazing animals and preserved from the destructive influence of excessive farming, the original conditions still prevail.

Today a part of the Plains (short grass) has been invaded by cacti, yucca, mesquite, shinnery (a low oak), and sagebrush. This invasion of desert plants has been the result of careless farming, over-grazing and burning, and years of decreased rainfall. In many parts, the grassland was so denuded of plants that strong winds picked up the loose top soil, carrying it for hundreds of miles in the so-called "dust storms," which added to the miseries of the last depression for farmers in that region.

Let us consider the grassland in its original climax condition. Approximately the eastern third of the biome was tall grass. This graded westward from tall to mixed and finally to a short grass area. On the western boundary of the biome was the so-called short grass. Consequently, three associations existed: the tall grass association, the

mixed grass association, and the short grass association. This area originally supported approximately 70,000,000 buffalo and great herds of antelope.

A few generalizations may be observed in the study of the grassland biome: (1) the similarity of the species of grasses found in the associations gives unity to the biome; (2) the large animals, which have had a decided effect on the biome, congregate in herds; (3) the smaller animals (badgers and prairie dogs) live in burrows; (4) the birds are all ground nesters; (5) most of the animals have keen, long range vision, and are extremely fleetfooted.

The prairie dog, among the smaller animals, plays an important part in the grassland. This animal lives in so-called prairie dog towns. The towns consist of numerous mounds with a series of ramifying tunnels leading down several feet below the surface. The prairie dogs nibble the grass very short on the mounds. They also carry seeds in great quantities into the tunnels. This burrowing habit permits soil aeration as well as the entrance of water into the soil. The prevalence of prairie dog mounds make them a vital factor in the grassland.

Few earthworms are found in the grasslands but ants are present everywhere. Undoubtedly the ant plays a role similar to that of the earthworm of the deciduous forest and may be called its ecological equivalent.

The sagebrush formation (*sagebrush-jack rabbit biome*): This biome includes the Great Basin Plateau between the Rocky Mountains and the Sierra-Cascade system. It covers most of Nevada, Utah, and parts of neighboring states. Winters are cold with limited rain or snow; summers are hot and dry with very little rainfall. Under these physical conditions sagebrush seems to thrive and is the characteristic plant of the region. Other principal plants are bunch grasses and various shrubs. Animal life includes many species of reptiles, birds, and mammals. The sage hen, largest of the American grouse, and many water birds about local ponds and marshes are resident members. Mammals include the jack rabbit, prong-horned antelope, coyote, badger, and occasionally larger forms that are also found in neighboring formations.

The desert formation (*creosote bush-kangaroo rat biome*): The American Desert occupies Southeastern California, a narrow strip of western Arizona, and the northwest part of Mexico. The substratum is usually rocky or sandy; the summer temperatures are extremely high; and water is scarce at all times. The true climax desert, contrary to popular conception, is not a sandy waste. The plants are usually cacti, some sage, and scattered grasses. The principal plants have no leaves.

UNIVERSITY OF MICHIGAN LIBRARIES

The plant body is adapted to the rigors of the desert climate, checking rapid evaporation of water. Consequently, the plants give the desert a unique appearance.

The animal life of the desert is adapted in a variety of ways to the arid climate of the desert. The land type of egg and the thick skin covered with scales make lizards and snakes well adapted to the rigorous life of this region. Most of the animal life is active only during the comparatively cool hours of the early morning and during twilight. The kangaroo rat is active at night when evaporation is low. During the day the rat spends its time very inactively in cool, deep burrows. The kangaroo rat, desert coyote, pocket mouse, red fox, night hawk, desert sparrow, desert wood rat, and antelope-jack rabbit are the principal animals.

The tropical rain forest formation: The tropical rain forest is located in Southern Mexico, Central America, Panama, and in the Keys of Southern Florida. The distinguishing and most influent factor here is, as the name implies, rain. Rain occurs daily during eight or nine months of the year. The other period constitutes what is called the "dry" season, during which only a few inches of rain falls during each month.

Because of this abundance of rainfall, plant life is teeming, and an extreme density of growth is the result. However, the density is largely among the tree tops, contrary to impressions gained from tangled "jungle" growths. The so-called "jungle" stage is not, however, permanent, and ultimately the rain forest climax will again be reached.

A curious phenomenon of this biome is the manner in which trees shed foliage. Trees shed their leaves throughout the year. One tree may be barren at any time; its neighbors may be fully leaved. And in a week barrenness may be replaced with a full foliage. Many of the trees grow to great heights, the first branches being sixty-five or seventy-five feet off the ground.

The principal animals of the rain forest are the monkey, tapir, anteater, armadillo, parrot, toucan, peripatus, land crab, tree frog, lizard, termite and ant. There are a few large animals and a few snakes.

In addition to the seven large natural formations already described there are numerous small transitional and successional communities. These include such communities as Bogs, Swamps, Desert Scrub, and Chaparral.

Vertical biotic zonation: It is interesting to note that the succession of biomes, from the tropical rain forest to the tundra, which reveals itself to a person traveling north from Central America to Alaska, may also be observed by one who climbs from a very deep valley to to a nearby high mountain peak. In other words, the horizontal biotic zonation of the earth is duplicated vertically. This is obviously due to the fact that physical environmental conditions, such as tem-

perature, light, and humidity, change with altitude as they do with geographical latitude. Roughly, a gain of 1,000 feet in altitude corresponds, from the viewpoint of mean temperature, to traveling 300 miles from the equator in a northerly direction.* On the North American continent, this vertical biotic zonation is illustrated most strikingly in the Grand Canyon of Arizona. The Canyon is a gorge 10 to 18 miles in width, and approximately one mile in depth, cut through solid rock by the water and silt of the turbulent Colorado River. A person standing at Point Imperial (elevation: 9,100 feet), on the North Rim of the Canyon actually see a succession of biomes as his eye wanders up from the subtropical vegetation fringing the river below through the semi-desert slopes and the grassy plateaus of the opposite wall, the patches of deciduous forest on the higher ledges and shelves of the rock; and coniferous forest of spruce, *Abies balsamea* and pinon pine upon the surface of the South Rim, at an elevation of some 8,000 feet; and finally up the snow-clad peaks of Mt. San Francisco, some 50 miles to the Southeast, rising to over 12,000 feet above sea level, where tundra conditions prevail.

* * * *

Marine communities: In the ocean, as well as on land, it is the physical and biotic factors that determine the type of plant and animal community and the interrelationships between its various members for a given area or vertical level. In general, three classes of marine communities, corresponding to land biomes, are recognized: the littoral, the pelagic, and the abyssal.

The littoral communities are found at the margin of the sea, near the shore line, roughly up to the one hundred fathom line. They consist chiefly of: (1) plants requiring the presence of light and of a substratum, such as algae fixed to the shore or bottom rocks; (2) minute plants (algae) floating upon the surface of the water and known collectively as *phytoplankton;* and (3) animals feeding upon these algae as well as upon the waste of the land, such as many mollusks, crustaceans, and worms; and (4) animals feeding upon smaller littoral animals, such as larger fishes, starfishes and their allies, and marine birds subsisting upon fish.

The pelagic communities are those of the open sea. They consist of phytoplankton, *zooplankton* consisting of minute floating animals, such as Protozoa, some annelid worms, some crustaceans, and jellyfish, and *nekton*, namely animals able to swim powerfully, even against

* Teisserenc de Borb found that the temperature in the troposphere decreases at the rate of 3 degrees F. per 1,000 feet. From the mean annual temperature maps it can be seen that the temperature decreases by about 10 degrees F. for a northward displacement of 500 miles within continental regions.

From these two relations one may conclude that an increase of altitude of 1,000 feet will correspond to a northward displacement of from 150 miles to 200 miles, but not much more in the latitudes in which the United States lies. In equatorial regions the isothermals are different and the northward variation could correspond to as much as 300 miles for 1,000 feet change in altitude.

sea currents. Whales and many fishes are residents of this community. Numerous littoral animals have pelagic larvae, so that they are littoral at one stage of their life history and pelagic at another. Thus, some tunicates (sea squirts) are mostly littoral animals which attach themselves to the sea-bottom of the littoral zone, but have pelagic free-swimming larvae. Some annelid worms, normally littoral, become pelagic during the breeding season.

The abyssal communities consist of organisms living at great depths in the sea and using the sea-bottom as a substratum. Due to the inaccessibility of these levels of the ocean, these communities have not been sufficiently explored. So far as it is known, however, no plants can exist in the abysses of the sea. The animals must be adapted to the absolute darkness, to the high pressures of the watery medium, and to the absence of currents prevailing there. Some sponges, echinoderms, mollusks, crustaceans, and fish have been identified as abyssal forms.

We have seen how the kind of plant life characteristic of any particular formation or community is largely determined by the kinds of physical factors that are present. Green plants depend largely upon sunlight, soil minerals, and water. These physical factors and the kind of plant life in turn determine to a large extent the kind of animal life present in each community. It becomes increasingly clear that each particular set of climatic and other environmental conditions as exemplified in the biomes were not always as they are today. Physical changes within the biome sometimes requires change on the part of some of its organisms; otherwise the latter are no longer capable of surviving. Over a long period of time, *nature* (the physical and biotic environment of the organism) gradually selects those forms best adapted to compete successfully for the available food, shelter, mates, etc., and thus to become established in a given region.

* * * *

Biotic succession: Hills, plateaus, and mountains are gradually being destroyed by erosion due largely to wind and water; ponds, rivers, and lakes are gradually disappearing because of a filling-in process of soil and the bodies of dead plants and animals. This means that there is a general leveling-off process going on. Coincident with the approach of land to sea level is an increase of moisture in the air and soil. Counteracting this global leveling-off process are such catastrophic phenomena as earthquakes and the less dramatic phenomena of the slow rise and fall of the earth's surface in various parts of the world.

One should not form the idea that within the great biotic formations (biomes) there is absolute uniformity in communities of plants and animals. In every biome there are minor differences in climate and sub

stratum which result in differences in flora and fauna. There are always relatively small areas in every biome being destroyed by fire, flood, or erosion. When the flora and fauna of a given area is suddenly destroyed, the area does not remain very long without a population. The process of redevelopment of a community proceeds as soon as the physical factors favorable for plant and animal life are reestablished. The first inhabitants gradually give way to others. The pioneers disappear; then transient followers are replaced by still later comers. Finally replacement is similar to that which was present before the area was denuded. This final stage is a community in a *state of balance* with its environment, which will not change except with changes of climate and environment. This natural and orderly change of the inhabitants in an area during its developmental history is called *biotic succession*. The final stage is called the *climax condition* and the community the *climax community*.

THE QUIZ SECTION

JULIUS SUMNER MILLER

Michigan College of Mining & Technology, Sault Ste. Marie, Michigan

1. A particle is projected vertically upwards, and is at a height h after t_1 sec., and again after t_2 sec. Find the height and the initial velocity.
2. Two cars start off to a race with velocity V_1 and V_2 and travel in a straight line with uniform accelerations a_1 and a_2. If the race ends in a tie find the length of the course.
3. A weight is suspended from one spring and has a period T_1; when suspended from another spring it has a period T_2. The springs are now hooked end to end and loaded with the same weight. Find the period.
4. A shot fired at an angle A hits the *foot* of a tower. If B be the angle subtended by the tower at this point find the elevation required to hit the top of the tower.
5. A particle is projected with a given velocity from a point P. The particle can pass through another point P' by two possible paths. Show that the product of the times of flight for these two paths is $2PP'/g$.

CONFERENCE ON THE TEACHING OF MATHEMATICS

The annual Conference on the Teaching of Mathematics at Illinois State Normal University will be held Saturday, April 23. This is scheduled from 9:00 A.M. to 3:00 P.M. and sponsored by the university department of mathematics.

There will be discussion groups centered around the problems of teaching mathematics in elementary and secondary schools. Particular attention will be given to participation in the Illinois secondary school curriculum program sponsored by the Office of the Superintendent of Public Instruction.

The speaker for the elementary session will be Dr. H. Van Engen, head of the department of mathematics, Iowa State Teachers College, Cedar Falls. Speaker for the secondary session will be Dr. Harold P. Fawcett, chairman of the department of education, Ohio State University, Columbus.

This is the second year such a conference has been arranged by ISNU teachers. Some 300 mathematics instructors from all parts of Illinois attended the conference held last spring.

UNIVERSITY OF MICHIGAN LIBRARIES

EASTERN ASSOCIATION OF PHYSICS TEACHERS
ONE HUNDRED SIXTY-EIGHTH MEETING

Rindge Technical High School
Cambridge, Massachusetts
May 15, 1948

10:00 A.M. Greetings—Mr. John W. Wood, Head Master, Rindge Technical High School
10:15 A.M. "Centrifugal Force?" Prof. Francis Sears, Massachusetts Institute of Technology
11:00 A.M. "Ultrasonics," Mr. Glen Roundie, Ultrasonics Inc.
11:30 A.M. "Audio-Visual Aids for Science Teachers," Russell Meinhold, Director, Rhode Island Committee on Audio-Visual Aids
12:15 P.M. Luncheon*
2:00 P.M. Business Meeting
2:15 P.M. Apparatus Committee, New Methods for Old Topics, Mr. W. Roscoe Fletcher, Chairman.

REPORT OF THE ONE HUNDRED AND SIXTY-EIGHTH MEETING OF THE EASTERN ASSOCIATION OF PHYSICS TEACHERS, RINDGE TECHNICAL HIGH SCHOOL, CAMBRIDGE, MASS., MAY 15, 1948

The association was greeted with the warmest welcome from the Head Master, Mr. John W. Wood. He recalled that the E.A.P.T. was the first association that he joined after becoming a teacher of science, physics, many years ago. During his brief remarks he stressed the fact that his fingers have been at the pulse of physics ever since he was first connected with the subject. Like the physics teachers of today he "never finished the book" in spite of its scant 200 pages and the ten periods a week.

The first lecture of the morning session was given by Prof. Francis Sears of Mass. Institute of Technology, on "Centrifugal Force?" Prof. Sears emphasized the fact that the question mark was a part of the title.

Prof. Sears pointed out that the problems in circular motion "are not all solved yet for many teachers do not know all the facts yet."

His presentation concerned itself with the forces acting on a ball and string while swinging so that the string generated a cone. "What keeps the ball outward is the question to be solved." The answer is that the ball does not stay out but is constantly falling to the center. The resultant of the forces acting on the ball cause it to fall constantly to the center.

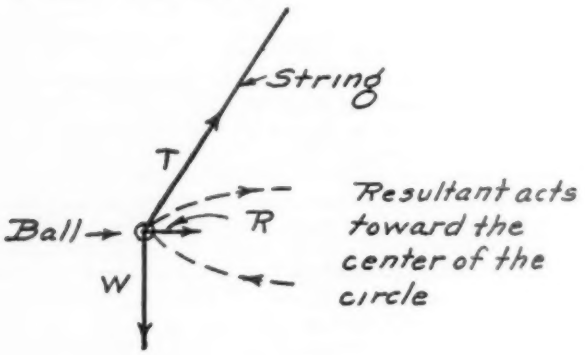


FIG. 1

What keeps the ball out or up can best be answered by use of a swinging ball in a vertical circle this time.

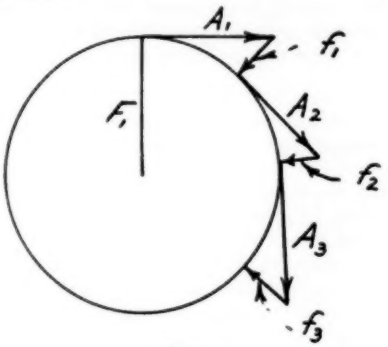


FIG. 2

Bodies of matter do not alter their motion in any way except as the result of forces applied to them. This is Newton's first law. Vectors A_1, A_2, and A_3 represent the force and direction that the ball would take if free to continue in its path without the force vector F_1 acting. Because of the forces represented by f_1, f_2, and f_3, the ball is acted upon, and the ball is really falling to the center at all times. The ball really falls and falls faster than a freely falling body.

It is useful with the brighter pupils to make use of the D'Alembert principle to help explain the phenomena, but generally speaking it is best with beginners in mechanics to make use only of Newtonian mechanics.

The second major speaker of the morning was a representative of Ultrasonics in Cambridge, Mr. Glen Roundie. His illustrated talk demonstrated the use of high intensity sound waves in industry and aviation.

The sound generator is not a true ultra sonic device as the frequency is easily within the range of the human ear. The term ultra was used in the sense that the waves were of very great amplitude. The most important uses are in dust and aerosol collection. . . . "The biggest single potential to date is aerosol agglomeration . . . practically any smoke, mist, or dust can be effectively recovered (in the case of fog, dispersed) with the new sound machine."

The new sound machine is a siren type unit driven by a variable speed air turbine. The pulsations are focused by horns to a reflector which directs the vibrations as required. The latest generators of this type operate over a frequency range of 1000 to 200,000 cycles per second with intensities of about 100 to 170 decibles. From 50 to 70 percent of the energy in the compressed air is converted into sound energy.

The first instillation was used at the Godfrey L. Cabot plant at Pampa, Texas on a small unit making furnace black from natural gas. "Here about 2000 cubic feet per minute is passed through the acoustic chamber where fine particles are agglomerated at a frequency of 3500 cycles per second and an intensity of 160 decibles. About 96 percent of the carbon black is recovered."

The action of the sound waves is to agitate the suspension to such an extent that they collide and adhere in agglomerates and are then passed through the cyclone separator.

There is great variety in the use of the ultra sonic generator:

1. Soda recovery from stack gases.
2. Soda and salt cake from stack gases.
3. Precipitating sulphuric acid mist.
4. Dust from flue gases.
5. Dispension of natural fog.
6. Drying of powdered soap.

Russell Meinhold of the State Department of Rhode Island was the last speaker of the morning session. He talked and illustrated "Audio-Visual Aids for Science Teachers." Mr. Meinhold stressed the fact that there was no best device but that all devices from a simple piece of apparatus or a photograph to the motion picture have their values when used by one who knows how to use the aid.

After lunch the apparatus committee under the able direction of Mr. W. Roscoe Fletcher of Worcester demonstrated both new apparatus and new uses for old apparatus.

The first to talk and illustrate was Mr. Russell from Cambosco. All his apparatus is listed in the new Cambosco catalogue.

Mr. Fletcher held forth for about one-half hour as follows:

"The contraction of a soap bubble until it assumes the minimum area, *viz.*: a plane surface covering the mouth of the thistle tube (or of the T.D. pipe) . . . the ascension of a soap film in an inverted funnel . . . these and cognate phenomena are usually interpreted correctly by the high school senior; extend this principle to the venerable, conventional wire frame, *F*, silk-thread-loop, *L*, soap film classic, and the student's explanation is far afield (Fig. 3 and 4); perhaps he has even deigned to read the lucid, succinct, textbook explanation . . . but with his eyes only and when his mind was on an Argonautic Expedition in search of the Golden Fleece; the assigned cause of the shape of *N* (Fig. 4) is contained in his terse, dogmatic dictum, 'the forces are equal in all directions'; this when analyzed, means that the radial-inward force exerted by the nothingness, *N*, is opposed by the radial-outward-force exerted by the somethingness of the soap-film, *B*; since these forces are (putatively) in equilibrium, there would be no motion of *L* so there would remain the irregular, unchanged shape of the initial filament-enclosure, *A*, *i.e.*, what happens could not happen; diminution of the area of *B* to the minimum, connotes an equal increase in the area of *A* to the maximum allowed by *L* which is fixed in linear magnitude; if *C* were indefinitely extensible by the diminutive film-force of *B*, then *B* would contract to a trifle

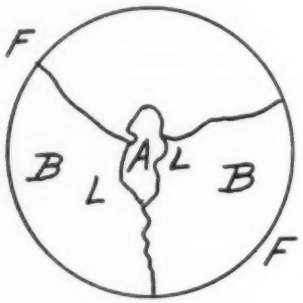


FIG. 3

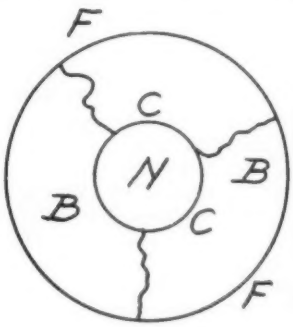


FIG. 4

more than nothingness, *i.e.*, *C* would extend until practically coincident with *F*. Though re-explained and discussed ad nauseam to a class, this student-statement-of-pseudo-principle persists, so that a correct answer in a final test is likely to be a mere parroting on too many papers. Table 1 may be tedious and incomprehensible to the pupil but likely to be a lucid, added proof and another viewpoint to the scholar. I do not know that anyone has published this phase of this phenomenon; the two latter facts may justify this exegesis. In Fig. 4 the silk filament, *C*, encloses a circle, *N*, which is a geometrical, plane, symmetrical figure; why does not *C* enclose any other of the infinite number of symmetrical figures, the number of sides of which are between the three of the triangle and the infinite number enclosing the circle?

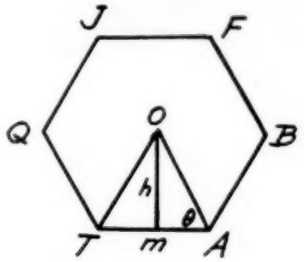


FIG. 5

Fig. 5 $ABFJQT$, a symmetrical figure, each side of which has a length of L linear units; its angles are A, B, F, etc.; $<\theta = 0.5$ of $< A$; h linear units in the altitude of ΔAOT; $L = AT$; n is the number of these isosceles triangles, each of which has an area of $0.5\ Lh$; $h/0.5\ L = \tan\ \theta$; $h = (0.5L\ \tan\ 0)$; area of triangle AOT $= 0.5L(0.5L\ \tan\ \theta) = 0.25\ L^2 \tan\ \theta$; area of the polygon is $= 0.25\ nL^2 \tan\ \theta$. Assume a perimeter of 3 linear inches for each symmetrical poligon of n sides in tabulation #1.

Tabulation #1

No. of sides	Area in Sq. In.
3	0.433
4	0.563
5	0.621
6	0.650
7	0.668
8	0.680
9	0.688
10	0.695
12	0.702
15	0.705
20	0.708
30	0.712
40	0.715
60	0.716
100	0.718
Circle	0.725

The circle has an area of $725/423 \doteq 1.676$ times that of the triangle of equal perimeter—maximum and minimum areas; the number of sides vary from 3 to infinity—their length varies from 0.75 to infinitesimal. Perhaps you can cajole your pupils to make a general geometric statement embodying the tabulated data and relevant to the behavior of the soap film.

The two dimensional loop has the maximum area for a given periphery; the three dimensional bubble has minimum area for a given volume. These two facts are frequently hashed by high school physics pupils. Data for the somewhat uncommon, geometrical solids #4 and #5 were empirically obtained from glass models; constants were deduced from these data; #3 cylinder has diameter equal to altitude; you are challenged to determine (for your own information) the value of a^3 using the icosahedron formula in Webster's International Dictionary, then obtain the result experimentally (vernier caliper and volume of a liquid displaced by the icosahedron), then compare the two results. Each solid tabulated in #2 is assumed to have a volume of 12 cubic inches. The area of these solids varies inversely with (not as) the number of sides: the sphere (infinite number of facets of infinitesimal area of each) has $\doteq \frac{2}{3}$ the area of a tetrahedron of like volume.

Tabulation #2

Geometric solid	No. of facets	Area in sq. in.
1. Tetrahedron	4	37.68
2. Hexahedron	6	31.50
3. Right cylinder	?	28.50
4. "Tetradecahedron"	14	27.29
5. Icosahedron	20	25.98
6. Sphere	Infinite	25.40

A dyne is the *CGS*, absolute unit of force, if acting continuously on a gram mass, will give to that mass an acceleration of one cm/sec/sec; is that unit more tangible or less so—its magnitude or diminutiveness made more obvious or less so when expressed as herein? I weighed 20 linear meters of #32 copper wire—determined the length of this which weighed $\doteq 1/980$ gm—enclosed this length in a glass tube with the typewritten legend: "the mutual attraction between the earth and this copper wire is $\doteq$ one dyne"—then hermetically sealed the tube to forestall twiddling and tampering.

A poundal is the *FPS*, absolute unit of force, which, if acting continuously on one pound of mass, will give to that mass an acceleration of one linear foot sec/sec; gravity gives to one pound mass an acceleration of $\doteq 32$ feet/sec/sec; then a poundal is $\doteq 1/32$ of a pound force, *i.e.*, it is $\doteq$ the mutual attraction between the earth and a 0.5 oz. mass; steel or aluminum rods of 0.5 ounces were enclosed as in the case of the dyne—enough specimens to distribute to each member of a class; and ask them the next day whether they have ever seen a dyne—the unwary will say "yes." Have they ever seen a volt, a lumen, a farad, a light year, a calorie?

An apparatus devised to test the mathematical ability of the advanced student and his comprehension of the Principle of Archimedes; an aluminum cylinder 24 inches long and 2 inches in diameter; four lead cylinders 2 inches in diameter and of such length that the lead balances the aluminum when both are in the air: the second lead balances the aluminum when both are immersed in water; the third in air balances the aluminum when immersed in water; and the fourth lead immersed in water balances the aluminum in air; using the aluminum cylinder as a basis, how would the student proceed to determine the length of each lead cylinder so that the lathe operator could cut each correctly the first time without resorting to the trial and error method. The first or second simulates more successfully the principle exemplified by the classic device—hollow brass sphere counterbalanced by the lead when both are in the air, but when both are in the evacuated space the sphere loses more buoyancy than the lead, so that the initial balance is upset; this lead aluminum combination does not require so sensitive a beam balance as does the so-called baroscope; it is certain to function as expected.

From a cleat on the ceiling of the North High School laboratory, ten pendulums are supported by bifilar suspensions which insure oscillation in the same plane; the longest pendulum is 360 cm—then the series 7/8, 6/8, 5/8, 4/8, 1/4, 1/9, 1/16, 1/25, and 1/36 of 360 cm respectively; all of these are stored in their respective depressions in a narrow board which is hinged on the ceiling cleat but rotatable through 180 degrees to hold or release the ten bobs; those of $L/4$ to $L/36$th have 2, 3, 4, 5, 6, respectively, times the frequence of the 360 cm pendulum; with these latter is an opportunity to test the students' sense of rhythm; let L, N and P be length, frequence and period of any unit pendulum, whether arbitrary or standard; let d, f, and t be length, frequency and period of any other pendulum; then $L/4$, $2N/1$, and $P/2$ is the fletcheresk mnemonic embodying the pendulum principles. From this mnemonic can be derived: $P \alpha \sqrt{L}$; $L \alpha P^2$; $\sqrt{L} : \sqrt{d} = P : t$; $L : d = P^2 : t^2$; $L : d = 1/f^2 : 1/P^2$; $N \alpha 1/\sqrt{L}$; $1/\sqrt{L} : 1/\sqrt{d} = f : N$; $\sqrt{L} : \sqrt{d} = 1/N : 1/f$, and seven other mathematical expressions—being for students, an anti-hide-bound exercise in variation and proportion.

A useful application of pendulum principles is a fletcheresk frame (template or jig) which aids the amateur musician in making a bifilar metronome which can be suspended from the "horns" of a metal music rack; the colored-string-marked suspension points give lengths to produce frequencies from 70 to 100 dvm—from largo to presto; this ten cent compact device gives perfect, isochronous periods which also is sometimes true of the ten dollar commercial, cabinet type of "time-keeper." Shall we give this device the ultra-modern, stilted, popular, innocuous, name of "PROJECT?"

I shall lose cast with my EAPT associates and they will be disappointed unless I deal with some phase of ACOUSTICS—so here goes. In my college days occurred an episode which had elements of instruction, exasperation, humor, potential danger, *et al.* Strings of a CONTRABASS viole (bull-fiddle, to the hoi polloi) are tuned to ≒40, 53, 72 and 96 dvs, respectively; to facilitate reading, the music is written an octave above actual pitch, bringing on or well nigh on the staff all of the two lower octaves. A fellow collegian purposed to resume contra-bass practice after many moons of abstention, during which time he evidently forgot a very essential detail—he attempted to tune the strings as written, necessitating four times the normal tension on each string; lacking sufficient strength, he applied a monkey wrench to the endless screw mechanisms thereby exerting

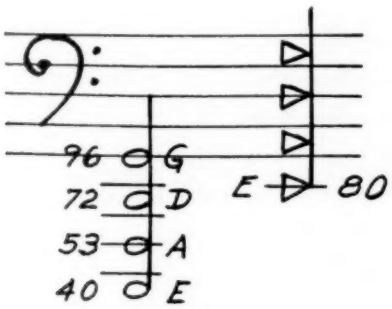


FIG. 6

enough force to lift a house; as results were unsatisfactory, he applied to me for information; I suggested that the instrument was CONTRbass and that he had attempted to tune it upward into the violoncello range (Great octave)—that no REAL artist uses a monkey wrench to obtain the required tension—that strings are now so tense that too much force is required to depress them to the finger-board, hence only slow execution is possible and that the normal low-pressure gave little string amplitude, hence small sound-volume; (subsequent measure proved that the 40 dvs string was 1.7 times the length of and 14 times cross-sectional area of my 80 dvs guitar string—the lowest pitch of the six). Argument or instruction was unavailing; returning to his room, he found that the knot of one string had pulled through its hole (on niche) in the tailpiece and its recoil had smashed the frame and glass of a picture on the wall above and behind the standing viol—the second string had broken and done other damage—the third string had wrecked the "peg" upon which it was wound. In the North High School class exercise (necessarily a "gang" experiment) we find that 65 pounds brings the 96 dvs string to normal pitch; $4 \times 65 = 260$ pounds to raise its pitch one octave above normal (determined by the "law of strings"—not empirically); the lower pitched strings are larger and require still more tension; total tension of 1200 pounds for the four strings is a conservative estimate when raised one octave each.

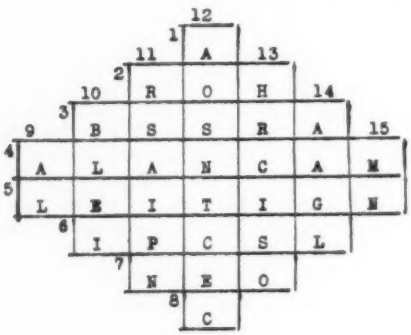
Max Planck, the father of quantum mechanics, was born at Kiel, April 23, 1858.

DICTOFORMS

P. H. NYGAARD
North Central High School, Spokane, Wash.

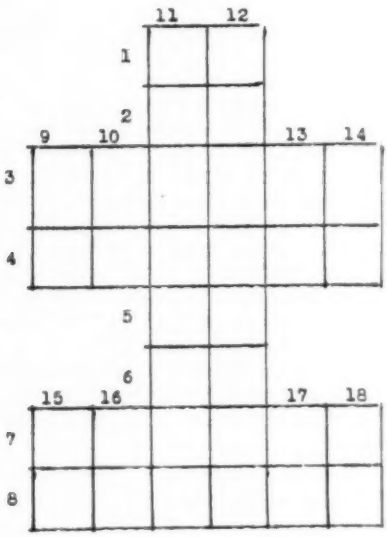
See the January 1949 issue of "SCHOOL SCIENCE AND MATHEMATICS" for a detailed explanation of this new type of recreation problem. Briefly, a "dictoform" is solved like a cross-word puzzle except that each word can have its letters arranged in any desired order. Only one arrangement, however, will tie in with the rest of the "dictoform." Which way is correct will not be always readily apparent nor easy to determine.

Solution No. 2



The correct words were as follows: 1. A. 2. RHO. 3. BRASS. 4. ALMANAC. 5. LIGNITE. 6. CLIPS. 7. ONE. 8. C. 9. LA. 10. BILE. 11. SPRAIN. 12. COSECANT. 13. CHOIRS. 14. ALGA. 15. MN.

DICTOFORM
No. 3



Horizontal Words

1. Music scale syllable following "Do."
2. Direction indicated by 45 degrees in the azimuth system.
3. Any member of the solar system, such as Mars, Venus, Saturn.
4. Temperature in degrees C equal to 86 degrees F.
5. Form of the article "*a*" used before words starting with a vowel.
6. Conjunction often used with "either."
7. Positive value of X in the equation, $X/40-40/X=1\frac{1}{2}$.
8. Curve formed by the intersection of a plane and a sphere.

Vertical Words

9. Nominative case of pronoun, him.
10. Abbreviation for the world's most populous city.
11. Name of a plane convex polygon that can have no diagonals.
12. Negatively charged unit found in the atom.
13. Chemical symbol for platinum.
14. Chemical symbol for radium.
15. Abbreviation for "chapter."
16. Abbreviation for the smallest state in the U. S.
17. Objective form of the pronoun "it."
18. First word of the King James version of Matthew 5:13.

EXPERIMENTS CONCERNING THE RESISTANCE OF WATER

MARTIN H. PATRICK
F. D. Roosevelt High School, Kulpmont, Pa.

The question: "Does water conduct electricity?" often arises in a science classroom. A few simple, yet highly fascinating, experiments can be demonstrated to bring out the fact that it is the impurity in the water which causes it to become a conductor.

Fill an ordinary drinking glass three-fourths full of hydrant water. Insert two metal rods (zinc, copper, aluminum, brass, etc.) into the water and separate them as much as possible. These rods are called electrodes. Connect an electric light bulb (sixty to one hundred watts) to one of the electrodes, and then to a male plug. The other electrode is connected to the remaining side of the plug. Insert the plug into a receptacle.

1. Note no glow. Drop a pinch or two of ordinary table salt into the water and note a faint glow. The reason that the bulb failed to glow in the first instance is that the water was rendered a poor conductor by nature herself, but upon the addition of salt it became a fair conductor as evidenced by the faint glow. Now the solution is called an electrolyte.

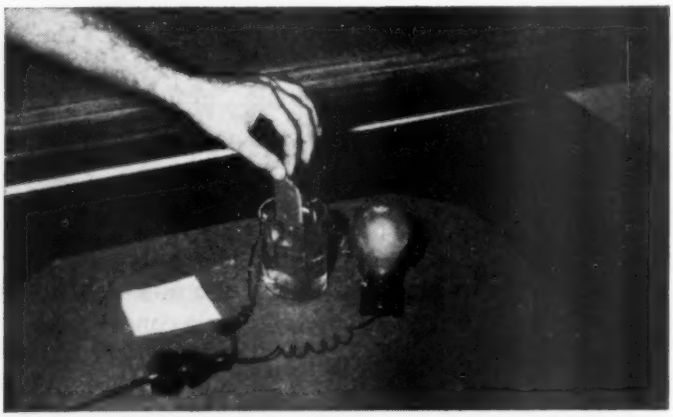
2. If the bulb is left to glow for a period of time, the electrolyte will become heated. The reason is that the current passing through the solution must overcome the certain amount of resistance represented in the solution, and thus causes heat.

3. Continue dropping salt into the water, and notice that the glow

of the bulb becomes increasingly bright. The salt has decreased the resistance of the solution.

4. Continue dropping salt into the water until you have reached a point where salt no longer adds to the glow. This is known as a saturated, or in the case of too much salt, a supersaturated solution. Now short circuit the electrodes by connecting a length of wire from one to the other. Notice a slight increase in the glow. This demonstrates simply that salt water will not conduct a current so readily as will a short piece of wire. Despite the fact that the potential drop (voltage) across the electrodes is about three volts, the current is of sufficient intensity to produce the noticeable glow.

5. Disconnect the plug. Remove one of the electrodes from the solution, and then replace the plug. Insert the electrode that you just removed back into the solution so that it barely touches the water,



A Piece of Cardboard Between the Electrodes Momentarily Causes Light to Cease Glowing

and notice an exceedingly feeble glow, accompanied by a sizzling of the water at the point of contact. Slowly lower the electrode into the electrolyte and notice a gradual increase in the intensity of the glow. The reason is that a greater current will flow through the circuit if the space area of the electrodes is increased. You can prove the same by filling the glass with more water and leaving the electrodes in a fixed position.

6. Prepare a new solution by adding just enough salt to cause the bulb to glow faintly. With the electrodes in the electrolyte, and the bulb barely glowing, insert a piece of cardboard between the electrodes and the glow will disappear for a few seconds only to return when the cardboard becomes saturated with the salt water. The

reason is that the dry cardboard acted to prevent a flow of current between the electrodes; but upon absorbing enough of the solution, it restored the flow. If you substitute wood or glass for the cardboard, the glow will disappear completely.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2106, 8. *Albert Franklin Gilmon III, Chicago.*

2112, 7, 8. *W. R. Talbot, Jefferson City, Mo.*

2114. *C. W. Trigg, Los Angeles.*

2119. *Proposed by V. C. Bailey, Evansville, Ind.*

Prove that

$$\cos^4\frac{\pi}{9}+\cos^4\frac{2\pi}{9}+\cos^4\frac{3\pi}{9}+\cos^4\frac{4\pi}{9}=\frac{19}{16}.$$

Solution by W. J. Cherry, Berwyn, Ill.

$$\cos^4\frac{\pi}{9}=(\cos^2 20^\circ)^2=(\tfrac{1}{2}+\tfrac{1}{2}\cos 40^\circ)^2=\tfrac{1}{4}+\tfrac{1}{2}\cos 40^\circ+\tfrac{1}{4}\cos^2 40^\circ \qquad (1)$$

$$\cos^4\frac{2\pi}{9}=(\cos^2 40^\circ)^2=(\tfrac{1}{2}+\tfrac{1}{2}\cos 80^\circ)^2=\tfrac{1}{4}+\tfrac{1}{2}\cos 80^\circ+\tfrac{1}{4}\cos^2 80^\circ \qquad (2)$$

$$\cos^4\frac{4\pi}{9}=(\cos^2 80^\circ)^2=(\tfrac{1}{2}+\tfrac{1}{2}\cos 160^\circ)^2=\tfrac{1}{4}+\tfrac{1}{2}\cos 160^\circ+\tfrac{1}{4}\cos^2 160^\circ. \qquad (3)$$

Adding the right-hand members of (1), (2) and (3) we get

$$\tfrac{3}{4}+\tfrac{1}{2}(\cos 40^\circ+\cos 80^\circ+\cos 160^\circ)+\tfrac{1}{4}(\cos^2 40^\circ+\cos^2 80^\circ+\cos^2 160^\circ). \qquad (4)$$

Now, since $\cos 160^\circ = -\cos 20^\circ$, the second term of (4) is easily shown to be 0; and, by the method of (1), (2) and (3), the last term is shown to be $\frac{3}{8}$. Therefore, with $\cos^4 3\pi/9 = 1/16$, we get

$$\cos^4\frac{\pi}{9}+\cos^4\frac{2\pi}{9}+\cos^4\frac{3\pi}{9}+\cos^4\frac{4\pi}{9}=\frac{3}{4}+\frac{3}{8}+\frac{1}{16}=\frac{19}{16}.$$

Other solutions by: C. W. Trigg, Los Angeles City College; W. R. Talbot, Jefferson City, Mo.; Francis L. Miksa, Aurora, Ill.; Hugo Brandt, University of Md.; V. C. Bailey, Evansville, Ind.; Norman Anning, University of Mich.; V. C. Bailey, Evansville, Ind.

2120. *Proposed by Felix John, Ammendale, Md.*

Solve for x:

$$\tan x+2\tan 2x+4\tan 4x=\cot x.$$

Solution by C. W. Trigg, Los Angeles City College

$$\tan\theta-\cot\theta=\frac{\tan^2\theta-1}{\tan\theta}=\frac{-2}{\tan 2\theta}=-2\cot 2\theta.$$

Using this identity we progressively reduce the given equation as follows:

$$4\tan 4x+2\tan 2x+\tan x-\cot x=0.$$
$$4\tan 4x+2\tan 2x-2\cot 2x=0.$$
$$4\tan 4x-4\cot 4x=0.$$
$$-8\cot 8x=0.$$
$$8x=\frac{\pi}{2}+k\pi, \qquad (k=0, 1, 2, 3, \cdots)$$
$$x=\frac{\pi}{16}(2k+1).$$

The eight principal values of x are $\pi/16$, $3\pi/16$, $5\pi/16$, $7\pi/16$, $9\pi/16$, $11\pi/16$, $13\pi/16$, $15\pi/16$. This equation may be generalized to

$$\tan x+2\tan 2x+2^2\tan 2^2x+\cdots+2^n\tan 2^nx=\cot x.$$

This reduces to $-2^{n+1}\cot 2^{n+1}x=0$, so the solutions of the equation are

$$x=\frac{\pi(2k+1)}{2^{n+2}}.$$

Other solutions by: Max Beberman, Shanks Village, N.Y.; Francis L. Miksa, Aurora, Ill.; W. R. Talbot, Jefferson City, Mo.; Aaron Buchman, Buffalo, N. Y.; Felix John, Ammendale, Md.; W. J. Cherry, Berwyn, Ill.; Hugo Brandt, Univ. of Md.; Charles Salkind, Brooklyn.

2121. *Proposed by C. W. Trigg.*

Find the unique number of 5 digits of the form *abccc* whose square diminished by unity is a permutation of 1, 2, 3, $\cdots$, 9.

Solution by W. R. Talbot, Jefferson City, Missouri

Let N be *abccc*. From N^2 we find $11111 < N < 31426$. It is given that $N^2-1 = (N+1)(N-1)\equiv 0 \pmod 9$. We notice that $N+1$ and $N-1$ differ by 2; thus, one quantity or the other, but not both, is a multiple of 9. For the same reason only one is a multiple of 3.

Then

$$N\equiv 8 \pmod 9 \quad \text{or} \quad N\equiv 1 \pmod 9$$
$$a+b+3c\equiv 8 \pmod 9 \qquad a+b+3c\equiv 1 \pmod 9$$
$$a+b\equiv 2 \pmod 3 \qquad a+b\equiv 1 \pmod 3.$$

The last three digits in N are determined from $3c^2, 2c^2, c^2-1$. By direct observation or trial, we eliminate $c=0$, 1, 3, 5, 6, and 9. Of the possible values of c, the following (omitting duplications of digits) satisfy the congruences (mod 9) where the corresponding values of a and b satisfy the congruences (mod 3):

$N\equiv 1$	a	b	c	$N\equiv 8$	a	b	c
	1	3	2 or 8		1	4	7
	1	6	4 or 7		2	0	8
	2	5	4 or 7		2	3	4 or 7
	3	1	2		2	9	8

Checking the values in N^2 shows duplications of digits for all numbers except 13888. Then $13888^2-1=192876543$, as required.

Other solutions also offered by: V. C. Bailey, Evansville, Indiana; C. W. Trigg, Los Angeles City College; Max Beberman, Shanks Village, New York; Edward Churchill, Schenectady, New York; Hugo Brandt, University of Md.; Francis L. Miksa, Aurora, Ill.

2122. *Proposed by C. W. Trigg, Los Angeles City College.*

If the sides of a right triangle are integers, then the radii of the inscribed and escribed circles are also integers.

Solution by Aaron Buchman, Buffalo, New York

If a, b, c are the sides of right triangle ABC, right angle C, it is easily shown that

$$r=\frac{ab}{a+b+c}, \quad r'=\frac{ab}{-a+b+c}, \quad r''=\frac{ab}{a-b+c}, \quad r'''=\frac{ab}{a+b-c}$$

where r is the inradius and r', r'', r''' are the exradii (see *College Geometry* by Altshiller-Court).

But a well known relation states that if the sides, a, b, c of right triangle ABC are integers,

$$a=v(x^2-y^2), \qquad b=2vxy, \qquad c=v(x^2+y^2)$$

where v, x, y are integers.

In the expressions for r, r', r'', r''', replacing a, b, c in terms of v, x, y and simplifying, leads to the relations, $r=vy(x-y)$, $r'=vx(x-y)$, $r''=vy(x+y)$, $r'''=vx(x+y)$.

Thus if a, b, c of right triangle ABC are integers, r, r', r'', r''' are also integers.

Solutions also offered by: V. C. Bailey, Evansville, Indiana; C. W. Trigg, Los Angeles City College; Francis L. Miksa, 613 Spring St., Aurora, Illinois; Hugo Brandt, University of Md.; J. Slavin, 1730 E. 18th St., Brooklyn 29, New York; W. R. Talbot, Jefferson City, Missouri.

2123. *Proposed by W. L. St. John.*

Find a necessary and sufficient condition that the roots of $x^3+fx^2+gx+r=0$ taken in some order shall be in geometric progression.

Solution by W. R. Talbot, Jefferson City, Missouri

Necessary Condition

Let the roots of the given equation be a/k, a, ak. Then by the relations between

roots and coefficients, $f=-a(1+k+k^2)/k$, $g=a^2(1+k+k^2)/k$, and $r=-a^3$. It is evident that $g=-af$; hence, $g^3=f^3r$.

Sufficient Condition

Submitted by Norman Anning, University of Michigan

One Solution

If $p^3r=q^3$, then the roots of $x^3-px^2+qx-r=0$ are in G.P. of $x^3+pk^2+qk+r=0$.

Put $r=(q^3/p^3)$ and multiply through by p^3. $p^3x^3-q^3-p^4x^2+p^3qx=0$. By factoring, $(px-q)(p^2x^2+pqx+q^2-p^3x)=0$, call the roots x_1, x_2, x_3. Then $x_1=(q/p)$; $x_2x_3=(q/p)^2=(x_1)^2$.

Another solution

Write $p^3r=q^3$ in terms of the roots: a, b, c. Then, after some simplification,

$$abc(a^3+b^3+c^3)-b^3c^3-c^3a^3-a^3b^3=0.$$

This may be written

$$(a^3-bc)(b^3-ca)(c^3-ab)=0.$$

It follows that some one of the roots is the G.M. of the other two.

Other solutions were offered by: W. J. Cherry, Berwyn, Ill.; Max Beberman, Shanks Village, New York; C. W. Trigg, Los Angeles City College; J. Slavin, 1730 E. 18th St., Brooklyn, New York.

2124. *Proposed by Bessie Spillman, Dobb's Ferry, N. Y.*

If $\cos A+\cos B=4\sin^2 C/2$, where A, B, C are angles of a triangle, show that the sides a, b, c are in arithmetic progression.

Solution by Max Beberman, Shanks Village, New York

Since $4\sin^2 C/2=2(1-\cos C)$

$$\cos A+\cos B+2\cos C-2=0. \tag{1}$$

In (1) substitute for the cosines their values in terms of the sides of the triangle, based upon the Law of Cosines.

$$\frac{b^2+c^2-a^2}{2bc}+\frac{a^2+c^2-b^2}{2ac}+\frac{a^2+b^2-c^2}{ab}-2=0. \tag{2}$$

Clearing fractions and adding and subtracting the indicated terms we have:

$$ab^2+ac^2-a^3+a^2b+bc^2-b^3+2a^2c+2b^2c-2c^3-4abc+a^2b-a^2b+ab^2-ab^2=0. \tag{3}$$

Equation (3) thus becomes

$$(c-a+b)(c+a-b)(a+b-2c)=0. \tag{4}$$

The first two factors cannot be zero for the sum of two sides of triangle must be greater than the third side.

But

$$a+b=2c$$

which was to be shown.

Solutions were also offered by: Hugo Brandt, University of Md., Norman Anning, Univ. of Michigan; V. C. Bailey, Evansville, Indiana; C. W. Trigg, Los Angeles; Francis L. Miksa, Aurora, Ill.; W. R. Talbot, Jefferson City, Mo.; Aaron Buchman, Buffalo, New York.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school

classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

2103, 4, 5, 6, 7, 8, 12. *From the gymnasium, Leiden, Holland.*

Solutions to some of these problems were sent by R. David, P. Kuyper, D. Koek, B. Van Leeuwen, H. Braakman, P. Groeneveld de Boer, A. Hilgerson.

PROBLEMS FOR SOLUTION

2137. *Proposed by V. C. Bailey, Evansville, Indiana.*

If a point be taken within an equilateral triangle, such that its distances from the vertices are equal to the sides a, b, c of another triangle, show that the angles between these distances will be

$$60°+A, \qquad 60°+B, \qquad 60°+C.$$

2138. *Proposed by Norman Anning, University of Michigan.*

In the equation $2x^3+2y^3-3x^2-3y^2+1=0$, if any rational value is assigned to x, show that at least one rational value can be computed for y.

2139. *Proposed by Norman Anning.*

Solve the set of equations:

$$x^2+xy+y^2=z^2$$
$$x+z=2y$$
$$(x+3)^2+(y+3)^2=(z+3)^2.$$

2140. *Proposed by Felix John, Ammendale, Md.*

Find a simple value for

$$\sqrt[3]{\frac{1\cdot 2\cdot 4+2\cdot 4\cdot 8+3\cdot 6\cdot 12+\cdots}{1\cdot 3\cdot 9+2\cdot 6\cdot 18+3\cdot 9\cdot 27+\cdots}}.$$

2141. *Proposed by Norma Sleight, Winnetka, Ill.*

Construct a triangle, given base a, the vertex angle, A, and the sum of the other sides, $b+c$.

2142. *Proposed by C. W. Trigg, Los Angeles.*

There is only one set of three distinct positive integers, having no common divisor, greater than unity, such that each is a divisor of the sum of the other two.

BOOKS AND PAMPHLETS RECEIVED

THE THIRD MENTAL MEASUREMENTS YEARBOOK, edited by Oscar Krisen Buros, *Director of The Institute of Mental Measurements, School of Education, Rutgers University*. Cloth. Pages xiv+1047. 18×25 cm. 1949. Rutgers University Press, New Brunswick, New Jersey. Price $12.50.

PRACTICAL TELEVISION SERVICING, by J. Richard Johnson, *Formerly Managing Editor, "Radio Maintenance Magazine"*; and J. H. Newitt, *Formerly Project Engineer, Federal Telecommunications Laboratory*. Cloth. Pages vii+334. 14.5×23 cm. 1949. Murray Hill Books, Inc., 232 Madison Avenue, New York 16, N. Y. Price $4.00.

FIRST YEAR COLLEGE MATHEMATICS WITH APPLICATIONS, by Paul H. Daus,

Professor of Mathematics, University of California, Los Angeles; and William M. Whyburn, *Professor of Mathematics, University of North Carolina, Chapel Hill.* Cloth. Pages xiii+495. 13.5×21 cm. 1949. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $5.00.

THE FACE OF THE MOON, by Ralph B. Baldwin, *East Grand Rapids, Michigan.* Cloth. Pages xiv+239. 16.5×24 cm. 1949. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Ill. Price $5.00.

A FIRST COURSE IN ALGEBRA, by N. J. Lennes, and J. W. Maucker, *Dean, School of Education, Montana State University.* Second Revision. Cloth. Pages xi+561. 13.5×20.5 cm. 1949. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.40.

KINETICS OF CHEMICAL CHANGE IN SOLUTION, by Edward S. Amis, *Professor of Chemistry, University of Arkansas.* Cloth. Pages ix+332. 13.5×21 cm. 1949. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $5.00.

ELEMENTARY CALCULUS AND COORDINATE GEOMETRY, by C. G. Nobbs, *Second Master, City of London School.* Part I. 255 pages. 13.5×21.5 cm. 1948. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $3.25.

PROBLEM BOOK IN THE THEORY OF FUNCTIONS. VOLUME 1. PROBLEMS IN THE ELEMENTARY THEORY OF FUNCTIONS, by Dr. Konrad Knopp, *Professor of Mathematics at the Uüiversity of Tubingen.* Translated by Dr. Lipman Bers, *Associate Professor of Mathematics at Syracuse University.* Cloth. Pages viii+126. 10.5×16.5 cm. 1948. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.85.

LIMITATIONS OF SCIENCE, by J. W. N. Sullivan, *a mathematician, musician, and philosopher.* Paper. 192 pages. 10.5×13 cm. The New American Library of World Literature, Inc., 245 Fifth Avenue, New York 16, N. Y. Price 35 cents.

EDUCATION IN VENEZUELA, by Delia Goetz, *Specialist in Education in Latin American Countries, American Republics Section, Division of International Educational Relations.* Bulletin 1948, No. 14. Pages v+104. 14.5×23.5 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 30 cents.

EDUCATION IN PANAMA, by Delia Goetz, *Specialist in Education in Latin American Countries, American Republics Section, Division of International Educational Relations.* Bulletin 1948, No. 12. Pages v+90. 14.5×23.5 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 25 cents.

FUNDAMENTAL EDUCATION. Three Sections of Fundamental Education—Definition and Program by the Secretariat of the United Nations Educational, Scientific, and Cultural Organization. Bulletin 1948, No. 13. Pages x+28. 15×23 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 10 cents.

SOURCES OF FREE AND LOW-COST MATERIALS. 1948 Revised. 17 pages. 20×27 cm. Aviation Education Division, Civil Aeronautics Administration, Washington 25, D. C.

BIBLIOGRAPHY OF MATHEMATICAL MOTION PICTURE FILMS, FILM STRIPS, SLIDES AND STEREOGRAPHS, by Perry A. Chapdelaine, *Department of Mathematics, Iowa State Teachers College, Cedar Falls, Iowa.* 41 pages. 15×23 cm. Price 75 cents, plus postage.

PRAKTISCHE MATHEMATIK, FÜR STUDIERENDE DER TECHNIK UND ZUM SELBSTSTUDIUM von Dr. Adolf Hess, *ehemals Professor am Kantonalen Technikum in Winterthur*. Paper. Pages 116. 13×21 cm. 1947. Rascher Verlag, Zürich.

BOOK REVIEWS

MENDELEYEV, THE STORY OF A GREAT SCIENTIST, by Daniel Q. Posin. Cloth. Pages xii+345. 15×22 cm. 1948. Whittlesey House, McGraw-Hill Book Company, Inc. 330 W. 42nd Street, New York 18, N. Y. Price $4.50.

This excellent bibliography is one that should be read by every student of chemistry, for it portrays the life of the Russian chemist, Mendeleyev, in a manner that holds your breath and attention to the very end. One sighs that all good things should come to an end as does this story with the chapter "Once There Lived and Existed . . . ."

Posin, in the first English biography of the life of this famous Russian chemist, tells of the indefatigable desire of Mendeleyev to become a scientist in spite of the overwhelming odds that existed for the peasant class during the pre-revolutionary days of 19th century Russia.

The biography tells of Mendeleyev's early youth in the village of Aremziansk, in the area of Tobolsk; the influence of his mother, Marie, manager of the glass factory in this remote Siberian village; the encouragement of Stepanov, the chief glass blower; and of the influence of Andrei, the chemist. Mendeleyev received his special interest in science from Bassargin, the Decembrist, who had traveled far and done much in Russian politics. At the age of seven, so goes the story, Mitya was surprisingly advanced in arithmetic computations and could discuss the dexterous glass handling operations with the men of the factory.

The story tells of Mendeleyev's struggle to be admitted to the University of Moscow and St. Petersburg, where he was finally accepted in 1850. From the start the young student stood head and shoulders above the advanced students.

The story of Mendeleyev's work on the periodic table and his predictions of the properties of elements then unknown, is an unforgettable story well worth the time to read. Although Mendeleyev is best known for his work on the periodic table, he like Pasteur of France, did much for his country in other areas of science such as teaching his country to win iron from the Urals, coal from the Donetz Basin, and oil from the regions of the Caspian Sea. Russia, according to Posin, owes much to its outstanding chemist for the country's expansion into industrial and scientific fields.

The book is unique in the generous sprinkling of authentic Russian words throughout. This was possible as Posin was born in Russia and lived in Siberia. Posin also included a few photographs of Mendeleyev and the Tobolsk region.

The book includes a bibliography of the principal published works of Mendeleyev, some 250, indicating the prodigious amount of work done by this famous chemist.

This is a book that must be read to appreciate Mendeleyev and to understand the Russian people!

KENNETH E. ANDERSON

PRACTICAL SPECTROSCOPY, by George R. Harrison, Ph.D., Sc.D., *Professor of Physics;* Richard C. Lord, Ph.D., *Associate Professor of Chemistry,* and John R. Loofbourow, Sc.D., *Professor of Biophysics, all of the Spectroscopy Laboratory, Massachusetts Institute of Technology.* Cloth. Pages xiv+605. 13.5×21 cm. 1948. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y.

The profession has needed a book of this type for a long time. In the first chapter the authors give a brief review of the history of spectroscopy, some of the techniques employed, and its uses in the various fields of chemistry, physics,

biology, medicine, metallurgy, and mineralogy. A general discussion of instruments, their selection and use follows. Important definitions are given and explained as they are needed. One chapter each is given to prism spectroscopes and to diffraction grating instruments. Illustrations are taken mainly from the catalogs and literature of the leading manufactures and designers such as the Gaertner Scientific Corporation, Adam Hilger, Bausch and Lomb, and others. A special chapter is given to the important topic of adjustment and care of instruments. Illumination, light sources, and photography are well discussed. Chapter 9 gives a brief discussion of the identification of spectrum lines. The first nine chapters give the general field and an excellent discussion of the principal instruments used.

Chapters 10 and 11 require a knowledge of recent theory to understand and follow the treatment of atomic and molecular spectra and molecular structure. These chapters are based on the laws of quantum mechanics, and while quantum numbers are explained, the space given is not sufficient for a complete understanding without considerable preliminary work. The second half of the book contains (1) an excellent chapter on the measurement of spectral intensities by radiometry and by photoelectric effects, and chapters on each of the following: (2) Photographic photometry, (3) Absorption spectrophotometry, (4) Qualitative spectrographic analysis of materials, (5) Quantitative spectrochemical analysis, (6) Spectroscopy of the infrared region, (7) Raman spectroscopy, (8) Spectroscopy of the vacuum ultraviolet (9) Interferometric spectroscopy. All of these topics are thoroughly discussed with drawings and photographs. Each chapter is closed with an excellent set of references. Two tables of the sensitive lines of the elements are given in the appendixes: (1) according to elements, (2) in order of wavelength. A brief review of less than a page is entirely inadequate for a book of this type. Every college library should have this book.

G. W. W.

ANIMAL FACTS AND FALLACIES, by Osmond P. Breland, Ph.D., *Associate Professor of Zoology, The University of Texas.* Cloth. Pages xvii×268. 13.5×20 cm. 1948. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $3.00.

This is a book for the general reader who is interested in learning about animals. In many respects it is constructed in a very unscientific form. It consists of many short stories, descriptions, suppositions, hunters' tales, facts and fiction about animals of many kinds. There is often no close connection between two paragraphs on the same or adjacent pages; *e.g.* Is the groundhog a good weather prophet? on page 50; Do racoons wash their food? page 51; What animal has a poisonous bite? page 52; etc. But it is reliable and interesting—more than can be said of some books advertised as great works of science. It consists of five main parts: Part I, Mammals; Part II, Birds; Part III, Fish; Part IV, Amphibians; Part V, Reptiles. Each part gives some important facts about a few of the animals in its division; some of the regular habits, some of the special characteristics, some of the idiosyncrasies, some of the little known variations and forms. It discusses legends, fallacies, fiction, and truth, backing the statements with measurements and the observations of great authorities. About a hundred good books and a dozen of the best magazines and journals are mentioned in the reference list. An excellent gift book.

G. W. W.

RADAR PRIMER, by J. L. Hornung, *Commander U.S.N.R., Supervisor of Radio-Electronics, Walter Hervey Junior College,* New York City. Cloth. Pages vi+219 13.5×20.5 cm. 1948. McGraw-Hill Book Company, 330 West 42nd Street, New York 18, N. Y. Price $2.80.

This book is exactly what the title indicates—a text which presents the essentials of radar without mathematical formulas or previous knowledge of electricity. Technical terms are explained as they are used and maps, pictures and

diagrams are abundant. The first four chapters discuss the radar equipment used on the ground or on boats. Chapter V gives the modifications for lighter sets to be used in the air. This is followed by a brief discussion of loran and sonar principles and the elements of television. Each chapter is concluded with a list of study questions, giving assistance to teachers who use this as a text. A well selected, brief bibliography of radio, radar, and television completes the book.

G. W. W.

A NEW GEOMETRY FOR SECONDARY SCHOOLS, Second Edition, by Theodore Herberg, *Head of the Mathematics Department, Pittsfield (Mass.) High School*, and Joseph B. Orleans, *Head of the Mathematics Department, George Washington High School, New York City*. Cloth. Pages vii+406. 13.5×20 cm. 1948. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $1.92.

This text provides a well organized sequence of materials designed to provide competence in geometric knowledge and reasoning, as contrasted to the point of view that geometry should serve as a vehicle for the study of logical reasoning processes. A minor compromise is effected by utilizing brief discussions of converse of a statement, analogous reasoning, and use of the indirect method in life situations. However these are presented primarily to facilitate the geometric work which follows.

An intuitive approach to the meaning of proof is made via definitions, postulates, and axioms. Single step proofs utilizing axioms are used to develop introductory theorems on angle relations. The conditions for triangle congruence, as well as some twenty odd "difficult" theorems, are assumed after being developed by inductive experimentation. Proofs for these are provided in a section at the back of the text, the student being told that he will be able to understand them better after he has experienced further work in geometry. The formal deductive type of proof is developed for use with application of congruent triangle relations. This appears to be rather abrupt in relation to previous work with single step proofs, and no mention is made of the syllogistic form which so readily makes this transition on a meaningful, rather than mechanical, basis for the student. Following continuing work with parallel lines other applications of congruent triangle properties are given and the analytic method is shown for determining the nature of the synthetic proof to be written. Basic work on constructions and loci is provided at psychological points with work on quadrilaterals. Chapters on circles and inequalities lead into more specialized work on constructions and loci. The balance of the text material covers the usual content with regard to similar triangles, right triangles, areas, and polygons.

Exercises are ample and well related to the principles being developed. Correlation is made with arithmetic, algebraic equations, and numerical trigonometry. Many interesting applications are shown, particularly from aviation. Provision for ability differences is made by a three level plan of content and exercise materials. Chapter reviews, tests utilizing items similar to those of testing agencies, lists of formulas, symbols, and abbreviations, tables of squares and square roots, and trigonometric functions complete the text.

For the purpose of presenting a thorough secondary school course in plane geometry this would seem to be an excellent text. However for those who feel that ability with logical reasoning processes is not an automatic outgrowth of the study of plane geometry, this can hardly be considered as "A New Geometry."

W. K. MCNABB
Hockaday Junior College
Dallas 6, Texas.

FUNDAMENTALS OF HEALTH AND SAFETY, by Grover W. Mueller, *Director of the Division of Physical and Health Education, The Board of Education, Philadelphia* and *Instructor* at *Teachers College, Temple University;* and Elizabeth

UNIVERSITY OF MICHIGAN LIBRARIES

Chant Robertson, *Department of Pediatrics, University of Toronto.* Cloth. 345 pages. 15×32 cm. 1948. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y.

This is an important book for use in high schools. Students of high school age have a keen awareness of the physical, mechanistic aspects of their environment, and they tend to remain most receptive to this sort of knowledge, which assumes ever greater importance in their needs for making a living. Few obtain an adequate knowledge of their own physiology and anatomy. *Health and Safety* offers this basic information in a readable style and from a practical approach.

The first chapter is an over-all survey of the importance of health. This is followed by thirteen chapters covering the various systems and structures of the body. Their function and importance are always explained from the student's point of view. Wherever appropriate, chapters contain practical information on the first-aid treatment of injuries, the proper care of the subject discussed, suggested diets, etc. The remaining six chapters of the book are devoted to the following: living in contact with others; narcotics, tobacco, and drugs; accident prevention; communicable and degenerative diseases; preventive measures; and public health service and administration. Each of the chapters is followed by a list of a review questions, multiple choice tests, and suggested individual or class activities; and each chapter also is accompanied by well-explained illustrations, charts, or other graphic materials. There is a glossary of terms at the end.

The above-average students in interest and enthusiasm might find this book slightly shy of information. These rare students, as in all cases, will need supplementary reading materials. *Health and Safety* is aimed at the average high school student. Its explanations are not long or technical, and they are easily understood. This book is very worthy of consideration as a text in health and hygiene courses.

GEORGE S. FICHTER
Miami University
Oxford, Ohio.

FUNDAMENTALS OF BUSINESS MATHEMATICS, Walter R. van Voorhis, *Associate Professor of Mathematics, Fenn College,* and Chester W. Topp, *Assistant Professor of Mathematics, Fenn College.* 14×20.5 cm. viii+454 pages, 1948. $3.75, Prentice-Hall, Inc., New York, N. Y.

This text is designed for business students in their first or second year of college. The material is taken from the materials in a course offered the past five years to students in Fenn College. Only the barest essentials of mathematics training is presupposed by the authors but emphasis is placed on speech, practice through timed tests and problems to be solved without the aid of pencil and paper. The verbal problems are numerous, placed where they check students' understanding of the process, require good thinking, and often require generalization of the original principle just developed. An exception is the set of problems on statistics, which are academic and do not require analysis after mathematical computation. The first two chapters on arithmetic operations and algebraic operations could well be omitted for students with a good mathematics background. However, most students could profit from some of the problems. Chapters III and XII deal with elementary statistics, including index numbers, control charts, standard deviation, the normal curve, correlation and trend lines. The discussions of these phases are good. Forty-seven pages deal with percentage, simple interest, discounts and partial payments. Chapter VI uses probability in mortality tables, value of expectation, and selection of defective parts. Seventy-one pages deal with algebraic operations with polynomials, graphs of first and second degree equations, exponents, radicals and logarithms.

Arithmetical square root is included. Chapter X deals with progressions and problems of finance and is very well done. Arithmetical series are applied to payments and simple interest while geometric series is used in annuity, compound

interest, amortization, etc. The book contains all the necessary tables in the back, including the American Experience Table of Mortality and the Table of the Normal Curve. Answers are provided for odd numbered problems and parts of others. If you have business students who have only a high school mathematics background and will take no further college mathematics, it seems to the reviewer this text would fulfill a definite need. The problems will also provide good self-help material, and the explanations are such the student could do a great deal for himself.

PHILIP PEAK

A FIRST COURSE IN ALGEBRA by Walter W. Hart, formerly *Associate Professor of Mathematics, School of Education, University of Wisconsin.* 14×21 cm., xi+389 pages, 1947. D. C. Heath & Co., Boston, Mass., $1.76.

This text is designed for ninth year algebra and is based on a previous book by the author, *Essentials of Algebra, First Course.* The appearance of the book is good, due to open pages, good problem spacing and paragraphing. There are many pictures which are placed so they will have functional value as well as motivate the student. In general, the text has been shortened over the previous one by omitting some of the starred work, such as; making formulas, formulas for other solids, thermometers, approximate roots of equations, functions of angles not found in tables, radicals and exponents. The problems have been decreased in number and difficulty but most ninth grade classes will still find challenging problem material. The standard topics are all well covered. The explanations do not give too much detail. Review lists of exercises are plentiful using about the same percentage of space as the general lists of verbal problems. Only 10% of the verbal problems deal with the quadratic equation. The book contains a pretest in the appendix to determine what part of chapters 1–3 should be studied. There are 22 pages of review material in the back of the book to be used concurrently with, or at the close of the course. The book is well indexed, can be had with or without answers, or separate answer booklets will be provided. As usual, Mr. Hart has produced a very teachable book.

PHILIP PEAK

A SECOND COURSE IN ALGEBRA, Walter W. Hart, formerly *Associate Professor of Mathematics, Education Department, University of Wisconsin.* 14×21 cm. ix+373 pages, 1947. D. C. Heath and Company, Boston, Massachusetts. $1.76.

This text is a revision of *Essentials of Algebra, Second Course* by the same author. The appearance of the book is changed greatly by the addition of photographs, drawings and opening of the page. The pictures are exceptionally well done from a functional point of view and can be used advantageously throughout the course. Each chapter has an introductory page giving historical or pertinent facts about the material being discussed. There are a great many exercises but not as many as usually given by the author. Some of the more difficult problems of the former text have been omitted. In developing the rules for operation with signed numbers, the laws of algebra are used up to the multiplication of a negative by a negative. This operation is not rationalized. The standard topics of third semester algebra are covered including series and a small amount on theory of equations. In the Appendix there are good practice problems with special references to text material. There are chapter tests, tables of squares and roots, four place logarithms, natural trigonometric and logarithm functions to ten minutes. This text will make a good sound course for third semester algebra students.

PHILIP PEAK

THE MATHEMATICAL BASIS OF THE ARTS, by Joseph Schillinger. Cloth. Pages x+696. 16.5×24 cm. 1948. Philosophical Library, New York. Price $12.00.

UNIVERSITY OF MICHIGAN LIBRARIES

This large volume of almost seven hundred pages presents a scientific theory of art production. All the arts are classified according to the organ of sensation through which they are perceived: touch, sight, hearing, smell, and taste. There is proposed a scientific, or engineering method of art production, as contrasted to the spontaneous, or artistic method; this method might well result in scientifically coordinating several arts in one. This would mean creation directly from mathematical principles, and not through imitation of appearances. To the painter, composer, or designer, this approach may yield many new and novel techniques. To the mathematician and the scientist such and approach may give an entirely new idea of the possibilities of the arts.

The mathematician or scientist reading the book will no doubt be dubious that he will thereby acquire facility in the field of art; the musician or painter may feel bewildered by page after page of mathematical symbolism. The mathematician will be bothered by the usage of terms with a different meaning than that to which he is accustomed—for example the word determinant now means the original value in a "style series," on page 110 he finds a graph of straight line segments called a sine curve (on the preceding page a sine curve appears to consist of semicircles placed alternately above and below a horizontal line). Likewise, the mathematician may be of the opinion that needless space is devoted to certain topics, for example, almost two pages are devoted to writing out all 120 permutations of the letters *abcde;* again one finds several pages devoted to writing out the binomial expansions of $(x+y)$ to the 2nd, 3rd, 4th, and 5th powers, again several pages are devoted to writing out circular permutations of 24 colors without any presentation of the binomial theorem. He is bothered by such concepts as the fact that positive rotation is clockwise; or by the unqualified statement, "on an ordinary graph, the unit of measurement is equivalent to 1/12 of an inch, and it represents, in this system of notation, the standard pitch-unit, i.e. $\sqrt[12]{2}$ (a semitone)".

Whether or not a creative artist would wish to adopt the theories presented in this book would be a matter of personal opinion. Certainly some knowledge of these laws of structure would be of value. The value of the book to the mathematician and the scientist is perhaps more questionable. Quite possibly the knowledge that such a work does exist is in itself of value. If there be merit in the theory, it may no longer be argued that mathematics is of no value in the field of art, music, and industrial design. In the opinion of the reviewer, however, the high school or small college library would need to consider carefully before selecting this book in place of two or three others which might be purchased for the same sum.

CECIL B. READ
University of Wichita

SPHERICAL HARMONICS, AN ELEMENTARY TREATISE ON HARMONIC FUNCTIONS WITH APPLICATIONS, by T. M. MacRobert, M. A., D.Sc., *Professor of Mathematics in the University of Glasgow.* Second Revised Edition. Cloth. Pages xv+372. 14×22 cm. 1948. Dover Publications, Inc., 1780 Broadway, New York 19, New York. Price $4.50.

The author's preface states the primary object of this text: to present the elements of the theory of the spherical harmonics without employing the method of contour integration. The book in addition covers a considerable body of related material.

The work provides a sound mathematical discussion of certain topics which arise in mathematical physics and engineering. A strong background of calculus, including differential equations, will be required in order to read the text. Although the material of some chapters depends to a great extent upon preceding developments, other chapters are to a large extent independent, and may furnish more extensive discussion than is available in certain other references. Examples of such chapters are those covering Fourier series, Bessel Functions, the hypergeometric function, the Legendre polynomials, the Legendre functions.

In general there is sufficient explanation to enable the mathematician to follow the physical problems without extensive background in physics, although some background would of course be valuable. The following may be mentioned as an example of some physical problems treated: conduction of heat, vibrations of stretched strings, potential theory and electrostatics, vibrations of a circular membrane.

About half of the chapters contain examples, in addition there is a collection of 88 miscellaneous examples. Many of these are of considerable difficulty. The book is of unquestioned value as a reference work; whether it is suitable for a text will of course depend upon the mathematical maturity of the students involved. It will probably be of greatest interest to the applied mathematician or engineer.

C. B. READ

THE METRIC SYSTEM OF WEIGHTS AND MEASURES. The National Council of Teachers of Mathematics: Twentieth Yearbook, Compiled by the Committee on the Metric System, J. T. Johnson, Chairman. Cloth. Pages xiv+303. 14.5×23 cm. 1948. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $3.00.

Since the development of the metric system of measures by the French in the late eighteenth century, rapid progress has been made toward the adoption of this system throughout the world. Now only the British Empire and the United States fail to use the metric system, even though they legally recognize its use. Various individuals and organizations have actively proposed the adoption of the metric system universally, and this yearbook focuses the attention of mathematics teachers upon the problem.

The discussion is made in four general parts using the compilation of individually written articles. Due to use of this method much repetition of material is found, particularly in illustrations and examples. In the first section articles describe the need for a system of measures, and the historical development of the metric system with trends toward its universal adoption. Section two presents the values of metric system use in various fields and offers a number of individual testimonials and organizational resolutions. Section three reviews publicity toward adoption of the metric system by radio programs. editorials and articles from newspapers, magazines, and technical journals. In the last section specific recommendations for making the change in general use and education are given. The appendix gives the various relations and equivalence tables for the metric and english systems of weights and measures.

In addition to the arousal of a crusading spirit in the reader, many valuable applications of mathematics and science are given. For mathematics teachers a complete teaching unit on the metric system for use in the junior high school is given. A most excellent article on computation with approximate data provides a meaningful approach and development of procedure methods for a topic sorely neglected or misused in nearly all present day textbooks on mathematics and science.

This yearbook should prove to be of interest and value to all science and mathematics teachers.

W. K. MCNABB
Hockaday Junior College
Dallas 6, Texas

ADVENTURES WITH ANIMALS AND PLANTS, by Elizabeth Kroeber, *First Assistant in Biological Science and Administrative Assistant at the Midwood High School, Brooklyn, New York;* and Walter H. Wolff, *Principal of the William Cullen Bryant High School, Queens, New York.* Cloth. Pages viii+600. 16×24 cm. 1948. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $3.20.

This new high school biology text attracts immediate attention because of its superb illustrations. The authors selected carefully from a wide variety of sources,

and as a result their book is well supplied with interesting and instructive photographs, drawings, and charts. Each is accompanied by a descriptive legend which is concluded by questions designed to stimulate further interest. And the answers to those questions, of course, are found in the main text.

There are ten units in the book. The first of these surveys the plant and animal kingdoms, briefly describing the major phyla and explaining the method by which plants and animals are classified. The second unit explains the basic similarity of all living things. This is followed by two units which describe the structure and functioning of plants and animals more in detail. The human species is used as the type specimen in the description of animal physiology. In the fifth unit, behavior is discussed, tracing the development of the nervous system from the most simple to the most complex animals and also explaining the response of plants to various stimuli.

The sixth unit is devoted to health. There are chapters on disease, some of the recent discoveries, methods of preventing the spread of disease, and suggestions for bettering health. Unit VII is on interspecific and intraspecific plant and animal relationships, pointing out the position which man must assume in maintaining a suitable balance in nature. This is followed by a unit on reproduction; a unit on heredity and environment as they relate to the development of the individual; and finally, a unit on evolution, in which the prominent theories are presented and discussed. Each of the chapters is followed by a list of questions, exercises, and suggested activities for further study on the topic considered.

Just as the authors were careful in their selection of photographs and in the organization of their material, they exercised a great deal of care in the method of presentation. They used a vocabulary which keeps the book at an appropriate readability level for high school students and a format which lends to ease of reading. This is a biology text which should receive wide usage. Its up-to-date material and skillful handling make it a valuable classroom text.

GEORGE S. FICHTER
Miami University
Oxford, Ohio

THE PACIFIC CHEMICAL EXPOSITION
JAMES O. CLAYTON

A display of the natural resources of the eleven Western States is to be a featured exhibit at the Pacific Chemical Exposition, an educational project of the two thousand members of the California Section of the American Chemical Society. Each state participating will be asked to show maps, mineral samples, photographs etc., and to have present one or more individuals competent to answer the technical and economic questions which will be put to them by the 25,000 chemists, chemical engineers and other technical and executive personnel expected to attend from industrial plants all over the world.

PHOTOSYNTHESIS

If someone had asked me to guess ten years ago which would come first, atomic energy or photosynthesis without the living plant, I would have guessed the latter.

We are just beginning to understand something about photosynthesis. With all the millions of dollars invested in agricultural research, it is strange that so little has gone into the fundamental process of photosynthesis which underlies all of agriculture.

—FARRINGTON DANIELS

. . . Scientific work must not be considered from the point of view of the direct usefulness of it. It must be done for itself, for the beauty of science, and then there is always the chance that a scientific discovery may become, like the radium, a benefit for humanity.—MARIE SKLODOWSKA CURIE.

CONTENTS FOR MAY, 1949

The Use of Resource Units in Teaching Mathematics—*Kenneth B. Henderson* 345

Progressing Toward November—*Charlotte L. Grant, President* 350

Laboratory Work Is Essential—*Traver C. Sutton* 351

Current Approaches in the Teaching of Science—*Miles Max Miller and Katharine Dresden* 359

From Blueprint to Action—*The Publicity Committee* 365

Science Instruction and the Laboratory—*Kenneth E. Anderson* 367

Astronomy in the Junior High School Curriculum—*Harry E. Crull* 371

The Quiz Section—*Julius Sumner Miller* 373

Dimensional Analysis: Applied to Elementary Mathematics—*Bernard E. Leventhal* 374

Seven Ingredients of a Life of Service—*John Y. Beaty* 377

Algebra Can Contribute to Reading Comprehension—*A. C. Nelson* 382

Motion Pictures for Elementary Science—*George Greisen Mallinson* 383

On Work and Energy—*James B. Davis* 391

The Folklore of Chemistry: A Sequel—*E. W. Blank* 392

Answering Children's Questions Through Science Experiences—*Anthony Cordell* 395

Elephants of Yesteryears—*James B. Cope* 402

A Practical Philosophy Concerning Mathematics—*Joseph J. Urbancek* . . . 405

The Laboratory Aquarium—*D. B. Blauvelt and B. H. Carleton* 414

Plant Morphology as a Living Subject—*Dorothy V. Phipps* 418

Optics Notes—*K. L. Yudowitch* 421

Problem Department—*G. H. Jamison* 422

Books and Pamphlets Received 428

Book Reviews 429

UNIVERSITY OF MICHIGAN LIBRARIES

WE COVER THE EARTH

School Science and Mathematics is read by subscribers in every state of the Union, all provinces of Canada, and thirty-three foreign countries.

It is owned by teachers, managed by teachers, and edited by teachers.

It comes to your desk every school month.

Interesting Articles in Volume 48

The Columbia Basin Project—Modern Trends in Mathematics Education—Covering Old and New Ground—Science for All—Some Ethical Implications of Science—The Control and Beneficial Use of Atomic Energy—A Museum Teaches—Phantom Forests—Putting Meaning into Geometric Concepts—Crater Lake—Geography in Farwestern Institutions of Higher Learning—Making the Most of Astronomy in High School Science—Developing Understanding in Junior High School Arithmetic—Map Clinic—Yearbooks and Science Education—What Makes the Weather Change? Fifth Grade Science Unit—Mathematics for the Other Eighty-five Per cent.

Helpful Reprints and Supplements

Atomic Energy: A Science Assembly Lecture, illustrated	.25
Mock Trial of B versus A—A play for the Mathematics Club	.30
100 Topics in Mathematics—for Programs or Recreation	.25
Poison War Gases	.20
Popular Mathematics: Bibliography	.10
Mathematics Problems From Atomic Science	.25
The Mathematics of Gambling	.20
Computations With Approximate Numbers	.25
The Radical Dream—A Mathematical Play for Puppets	.15
Geometry Theorems: A List of Fundamentals	.15
How Water Serves Man. A teaching unit	.20
Biology Reading List	.10
Won by a Nose. A chemistry play	.25
Some War-Time Developments in Chemistry—48 pp.	.50
Radioactive Isotopes: A Science Assembly Lecture, illustrated	.25
Kem: Two Games for Chemistry Classes	.15
Modern Periodic Arrangements of the Elements; illustrated	.25
Ion Visits the Realm of Air. A Play	.25
The King of Plants. A play for science clubs	.25
Three Families of Great Scientists: dramatized	.15
Some Lessons About Bees. A 32-page booklet; illustrated	.20
The Triumph of Science. A play for auditorium programs	.25
In a Sound Studio. A play: Physics and Music	.25
Science Library. Recent books for high schools	.10
Youth Looks at Cancer. A biology play	.25
Laboratory Work in Single Periods: Method	.15
Apparatus for Demonstrating the Fundamentals of Radio	.20
Science in the Grades: Practical Contributions—35 pp.	.30
Extracting Aluminum. A one act chemistry play	.15
Vitalizing Chemistry Teaching. A Unit on the Halogens	.15
Telescope Making Illustrated	.25
A Scientific Assembly Program, Wonders of Science	.30
What Is Scientific Method?	.20
The Scientific Method as a Teaching Procedure	.30
Elementary School Science Library	.10
Projection Demonstrations in General Science	.20
Atomic Energy—A Play in Three Scenes	.30

Orders for Reprints must be prepaid.

SCHOOL SCIENCE AND MATHEMATICS

Price $3.50—Foreign $4.00

No numbers published for July, August and September

P.O. Box 408 Oak Park, Ill.